THE EFFECTS OF PROACTIVE DIGITAL VIDEO GUIDE ASSISTANCE, LOCUS OF CONTROL, AND COMPUTER EXPERIENCE ON SUCCESS IN A COMPUTERIZED PROBLEM-SOLVING ACTIVITY

By

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Sebastian Foti

This dissertation is dedicated to the memory of
Donald C. Crowley

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This purpose of this study was to determine if there are differences in problem-solving outcomes between experienced and nonexperienced learners with varying locus-of-control orientations due to the effect of varied types of digitized video guide assistance available in a problem space. In addition, the study examines the perceptions of the subjects related to types of digitized video guide-based help intervention, problem difficulty level, and usefulness of help facilities.

Data were collected on 105 subjects, juniors and seniors at the University of Florida. Each subject responded to the Nowicki-Strickland Locus of Control Inventory, a one-page computer experience survey, and a computerized problem-solving activity. The problem-solving aspect of the treatment also contained eight attitudinal questions which incorporated a semantic differential scale. During the computerized problem-solving activity, either proactive or request-only help was given using digitized videos of male, bow-tie-wearing guide "assistant."

Logistic regression, multiple regression, and ANOVA were used to analyze the data. The results of the analyses ($p < .05$) revealed that offering proactive digital video guide help increases the likelihood that users will request help on their own, and users who do request such help are more likely to solve the problem correctly. Although results of the study indicate that locus of control and experience do not impact the likelihood of success with the problem-solving activity, locus-of-control orientation was found to be a significant predictor of whether the user will find digital video guide help useful and of whether the user will enjoy the problem-solving activity. Moreover, the more externally oriented the user, the more likely they will be to (a) find digital video guide help useful and (b) enjoy the activity itself.

The results of this study indicate that digital video guide assistance can be effective with beginners in a problem-solving activity. Because locus of control was found to be a significant predictor of certain user attitudes, its relationship, as well as the relationship of other social learning theory constructs to the man-machine interface merits further research.

CHAPTER 1
INTRODUCTION

Recent advances in computer technology and behavioral science have transformed the once educationally primitive domain of machine-mediated learning into a robust, vital area of research in which educators, cognitive psychologists, and computer engineers share visions of the future. Beyond using computer technology to present instructional materials using traditional delivery modes such as drill and practice, the linear tutorial, and question-answer interactions, today's system designers are applying human learning principles to computer systems at every level of operation. Brenda Laurel (1990) notes,

> Computers behave. Computational tools and applications can be said to have *predispositions* to behave in certain ways on both functional and stylistic levels. Interfaces are designed to communicate those predispositions to users, thereby enabling them to understand, predict the results of, and successfully deploy the associated behaviors. (p. 355)

Since communicating dispositions has been essentially a human task, it is natural that the metaphors used by some interface designers have been based on living organisms. This anthropomorphic view of the machine has yielded interfaces incorporating semi-intelligent animated "characters" that appear to perform many routine tasks for the computer user. These characters represent a system which may supply expertise, skill, and labor in response to the user's needs. As Laurel notes, "All of the computer-based personae that weave through popular culture have one thing in common: they mediate a relationship between the labyrinthine precision of computers and the fuzzy complexity of man" (p. 355). The form that these characters take has an effect on the user's perceptions of the system. For example, Apple Computer® Inc. has provided a variety of interface characters for the speech recognition software on Macintosh® AV computer systems. Some of these characters are human-like, and some are simple machine-like indicators similar to those found on a stereo amplifier. Although the functions fulfilled by these interface artifacts are the same, the metaphors used are very different. Functionally, these characters are designed to "guide" the user through the task at hand or act as "agents" to do specific tasks for the user. Although the computer industry has high hopes for systems which provide such assistance, very little research has been done to determine which pedagogical techniques are most effective under which pedagogical conditions.

This study uses a video character as a guide that assists the user in a problem-solving activity. The "video guide" in the study is an actual person who was filmed in a recording studio. The video guide offers help during the activity in one of two ways: either proactively, that is, automatically without being asked, or on-demand, when the user requests it. The video guide is displayed in a "Help Box" which is an area in the lower left corner of the activity space (see Appendix A). While the user is becoming familiar with the system, Help is context sensitive, that is, the assistance given is appropriate for user's situation.

The paucity of research in the field of Human Computer Interaction (HCI) is due in part to problems associated with conducting empirical research in the field. Early research attempted to apply strictly the scientific method in laboratory studies. According to John Carrol (1991) of the IBM Thomas J. Watson Research Center,

> The scientific method implies dichotomous contrasts, and this works well only if the required controls are possible and appropriate. In HCI these requirements are generally not met. . . . In HCI, the real world consists of various artifacts (software, hardware, documentation) embedded in contexts of work and social interaction. In constructing a science of HCI, we make an intermediary representation of this reality, usually involving selection and simplification. Barnard calls this a "discovery" representation. (p. 4)

Barnard (1991) believes strongly in the use of discovery representations and promotes the use of such interaction scenarios to assess how well a given HCI theory meets the actual needs found in the application domain.

The discovery representation used in this study incorporated an interaction scenario in which the user is involved in a computer-based logic problem-solving activity. This discovery representation will be referred to as the problem space. The study also incorporated the use of an animated digitized video character which will be referred to as a guide. The guide was used primarily in an advisory capacity, offering context-sensitive assistance.

Since Newell and Simon (1972) focused on the man-machine dialogue as a manifestation of a physical symbol system, research in the area of computerized advice-giving has been expanding rapidly (Carroll & McKendree, 1987). The use of a guide creates the illusion of a physical source for the advice. To some extent, it is one level of abstraction away from the programmer-user interaction found in traditional text-based systems.

Statement of the Problem

This study applied theories found in education and cognitive psychology to the application of guide-based help in interaction scenarios found in the growing field of Human Computer Interaction (HCI).

The study investigated three broad questions:

1. Does digital video guide-based help intervention support a user's efforts in a problem space?

2. Is the effectiveness of proactive digital video guide-based help affected by parameters such as locus of control and computer experience?

3. What factors contribute to the user's perception of the video guide-based help system?

Specifically, the study was designed to determine whether proactive, (system-initiated, context-sensitive) digital video guide-based help intervention can be more effective than on-demand (user-initiated, context-sensitive) help intervention alone. In short, the control of access to help could come from two sources, either the computer 'decides' or the user decides. In addition, factors that contribute to the user's perception of the digital video guide-based help features were examined.

The subjects in this study were undergraduate students at the University of Florida who were enrolled in introductory Instructional Computing classes who took a locus of control measure. Locus of control measures reflect the extent to which control over valued reinforcements is perceived as internally or externally oriented (Rotter, 1966). The treatments presented mediated learning experiences alternatively offered with on-demand guide assistance and automatic, proactive, system-initiated guide assistance to participants actively involved in the problem space.

Need for the Study

Incorporating a human character in the human-computer interface adds several dimensions to an advisory system. In addition to the media considerations that audio and video capabilities furnish, questions concerning the anthropomorphic qualities of the intellectual assistant become central. The 'role' of the computer character is also in question. Is the character viewed as being in some way in control of the interaction? The complexity of advisory systems is reflected in Jackson and Lefrere's (1984) statements:

> Advising is more than describing or demonstrating because it suggests both the existence of alternatives and the possibility of a preference on someone's part. Advising also suggests the

> existence of a problem, which may involve more than the mere lack of information. (p. 65)

On the other hand, the human character's more natural conversational approach to advice-giving seems superior to alternatives in other ways. Most current user interfaces employ a graphical user interface (GUI) to present information which may then be manipulated using iconic or textual tools. These direct manipulation interfaces, although powerful, present the user with "too much to do or see. Auditory I/O is a natural, available, and systematically underutilized channel for enhancing user-computer communication" (Mountford & Gaver, 1990, p. 320).

The concept of what is "natural" in an interface has been the topic of several speculative articles in the literature. Norman (1993) states, "Naturalness is actually specified as the complexity of the description of the mapping between the representation and the thing being represented" (p. 261). An informative summary of the anthropomorphic approaches to interface design was given in Eberts and Eberts (1989) and is reproduced in Table 1-1.

The issue of anthropomorphism in the interface has been confounded by the dichotomy between personification of the computer (e.g. "Please wait while I sort the list") and the use of actual anthropomorphic agents such as the one in this study. Several researchers (Shniedermann, 1987; Turkle, 1984) find the former undesirable and even deceptive. The character-based agent provides a backdrop for the powers of inflection and human dramatization and, moreover, for multiple representations of the same communication. Incorporating these human elements into the interface may actually make the computer itself less conspicuous, more invisible, and ultimately more of a medium.

Table 1-1

"Naturalness" In Human Computer Interaction

Concept	Reference
System should provide an image of its underlying processes to the user.	Fitter, 1979
Normal communication between individuals is examined to apply to the interface.	Kennedy, 1974
Formal communication theory applied to human computer communication.	Oberquelle et al., 1983
Constructive nature of human-human communication applied to man-computer interaction.	Thomas, 1978
Human and computer are seen as partners.	Press, 1971
Interface that is neither too under-determining nor too over-determining.	Thimbleby, 1980
Computer accepts, analyzes, and critiques user plans.	Langlotz & Shortcliff, 1983
System made more natural by being self-adaptive.	Innocent, 1982
Graceful natural language interaction.	Hayes & Reddy, 1983
Natural artificial languages.	Perlman, 1984

Source: Eberts & Eberts (1989)

Brenda Laurel (1990) claims that in order to serve the user best a system must provide (or be able to generate) multiple representations as well as *metaknowledge*, or knowledge about problem solving in a domain. Susann Brennan observes,

> Multiple representations increase the odds that the user and the system will be able to communicate effectively and that ambiguities in one representation will be disambiguated by another. (Laurel, 1990 p. 362)

Formerly ignored aspects of user interfaces are now central in the thinking of experts like Patricia Wright of the Media Research Center Applied Psychology Unit, Cambridge, England, who claims that "characteristics of the interface, in the broader sense of both the functionality provided and the form of its display, are not optional extras, but can have significant consequences" (Wright, 1989, p. 282). As the technology expands to include audio and video output, as well as guide and other on-line help platforms, there will likely be an increase in research focusing on these design characteristics.

Interface design characteristics, formerly the domain of educational software designers, are increasingly being analyzed by educators wishing to incorporate software in their teaching. In *Mindstorms*, Papert (1980) wrote about "the ways that choices made by educators, foundations, governments, and private individuals can affect the potentially revolutionary changes in how children learn" (p. 32).

Today, as Papert predicted, computer technology is being used to augment teaching and learning at many levels. Wenger (cited in Ohlsson, 1987, p. 215) reminds us that one function of teaching is the act of knowledge communication, even when it is carried out by an artifact. Binsted (1987) suspects that "learners hold strong stereotypes about tutor roles, so that when a talking head gives input or process information they see this as quite congruent with the stereotype" (p. 39). Given the emergence of desktop video capability in personal computers, teachers themselves may eventually become guides in their own productions.

The idea of electronic tutoring in general or of "forming an intellectual partnership between the student and tool" (Salomon, Perkins, & Globerson, 1991) has been the subject of many studies in the realm of artificial intelligence (for a survey of such systems, see Woolf, 1988). Salomon (1988) found that several functions found in computer tools may help build such an intellectual partnership, including (a) assuming some of the intellectual burden in experimentation, (b) presenting learners with novel alternatives, (c) freeing the individual from lower level operations, (d) displaying intermediate processes, (e) providing intelligent tutelage, and (f) providing models of information representation, processes and strategies. Conditions necessary for internalization of such functions are also described: (a) comprehensibility, (b) generalizability, (c) novelty, (d) utility, (e) explicitness, and (f) mindful abstraction.

In some form, all of Salomon's functions relate to on-line help, especially as it relates to activity in a problem space (i.e., the problem presented to the user), including the function regarding intelligent tutelage. On-line help systems often employ some intelligent decision-making features. In this study, for example, on-line help was given based on position in the problem space, previous help given, and an analysis of errors being committed. Currently, there is a great deal of research activity in this area, but "current research on intelligent advisory help facilities has not adequately addressed their utility and usability as a research issue" (Carrol & McKendree, 1987).

The study of Human-Computer Interaction as a discipline is attempting to provide system designers with a framework for evaluating design. By applying science through application "representations" such as the interaction scenario used in this study, theories may be developed and tested for applicability.

Background of the Study

There are a multitude of approaches to the concept of electronic problem solving. Many of these approaches attack the point between the user's view of the system and the functional or logical view of the system held by the system designer.

Several researchers (Hammond & Barnard, 1984; Ramey, 1989; Wright, 1989) who study computer user interaction point out the difficulty between using "instrumental" or process-related messaging (messages that do work, as in command language) and task-related commentary. Ambiguities in the presentation itself, called Escher effects, which force users to spend substantial time sharing attention between the task and rhetorical analysis, also complicate the design of help intervention. This suggests that it may be helpful (to the user) to separate the procedural messages and the more global metacognitive or strategy-related messages in on-line help.

The type of intervention supplied the user in a problem space may have a significant effect on the entire mediated learning experience. Dr. Reuven Feuerstein (1990) claims that

> the Mediated Learning Experience is responsible for a more meaningful and generalized type of change that actually assumes a structural nature. . . . Learners can benefit not only from the direct exposure to a particular stimulus, but they can also forge in themselves a repertoire of dispositions, propensities, orientations, attitudes, and techniques that enable them to modify themselves in relation to other stimuli. (p. 75)

According to Norman (1991), in a mediated interaction scenario "actions are performed through a feedback mechanism involving both an execution and an evaluation phase. Both phases of the action cycle need support from the representational format used by the artifact" (p. 23). In the action cycle, the interaction centers around the gulf between the user's goals, or what the user would like to happen and the environment or what Norman calls "The World." Focusing on discrepancies in the knowledge base as critical to problem solving stems from Otto Selz's post-Gestalt work on productive thinking and learning from error. Norman (1991) defines the situation as follows:

> The gulf of execution refers to the difficulty of acting upon the environment (and how well the artifact supports those actions). The gulf of evaluation refers to the difficulty of assessing the state of the environment (and how well the artifact supports the detection and interpretation of that state). (p. 23)

Bodker's (1989) description of the action cycle includes the idea of "activity flow." When a consistent, cohesive activity flow occurs between user and task, there is a feeling on the part of the user of direct engagement, and the process becomes automated. Bodker (1989) and Norman (1991) believe that interruptions in the activity flow are often disruptive of efficient performance.

It is not clear, however, whether help intervention is identified as an interruption or an intrinsic part of the human, task, artifact system. Norman (1991) states,

> Artifacts do not actually change an individual's capabilities. Rather, they change the nature of the task performed by the person. When the informational and processing structure of the artifact is combined with the task and the informational and processing structure of the human, the result is to expand and enhance cognitive capabilities of the total system of human, task, and artifact. (p. 19)

The human, task, and artifact system or, more simply, *augmentation* system (Engelbart, 1963) and its relationship to specific help intervention is at the core of the present study. In order to analyze the activity of the augmentation system itself, a computer program has been developed to track all help-related events. Help intervention which attempts to bridge the gulf of execution as well as the gulf of evaluation is supplied. In one treatment the help offered is proactive, that is, offered without request based on perceived need. In the second treatment, the same help is available on user request.

Purpose of the Study

This study was designed to determine if there are differences in problem-solving outcomes between experienced and nonexperienced learners with varying locus-of-control orientations due to the effect of varied types of digitized video guide assistance available in a problem space. In addition, the study examined the perceptions of the subjects associated with the types of digitized video guide-based help intervention, problem difficulty level, and usefulness of the help facilities.

Subjects and Procedures

Data were collected on 105 subjects enrolled in the Introduction to Instructional Computing course of the College of Education, University of Florida. The subjects were tested over three terms of 1993. Each subject responded to the Nowicki-Strickland Locus of Control Inventory, a one-page computer experience survey (Appendix B), and computerized version of the problem-solving activity "Coin Challenge" designed by Dr. Elroy Bolduc of the University of Florida. The problem-solving aspect of the treatment also contained eight attitudinal questions which incorporated a semantic differential scale (Osgood, Soci, & Tannenbaum, 1957). The experience survey and the locus of control measures were pencil and paper implementations and undertaken in a supervised classroom setting. The computerized portion of the treatment was carried out in a computer lab outfitted with 17 Macintosh LCII computers. Subjects were randomly placed at computers alternately set up to offer proactive system-initiated help or manual on-demand help for the first activity. During the second activity the type of help offered was switched. After the completion of the second activity, the subjects were given a preference indicator and asked if they would like to do the activity a third time. Those that did were allowed to choose the type of help intervention used. An audit trace of all subjects' activity was kept by the Coin Challenge program.

Research Questions

The research questions addressed in this study fall into three categories designed to investigate the somewhat broader questions:

1. Does digital video guide-based help intervention support a user's efforts in a problem space?
2. Is the effectiveness of proactive digital video guide-based help affected by parameters such as locus of control and Experience?
3. What factors contribute to the user's perception of the video guide-based help system?

Data were gathered from a trace of the subjects' behavior during the problem-solving activity and from responses to attitudinal questions. The attitudinal questions queried the participants as to whether or not they enjoyed the problem-solving activity, whether or not they found the video guide-based help useful and which type of guide-based help they preferred. Variables in the study were analyzed using the predictors: locus of control index, computer experience index, proactive help status, perceptions of their own problem-solving ability, estimations of the difficulty level of the problem, and the associated interactions.

The following research questions were addressed by this study:

1. Is there a significant difference in achievement (i.e., the ability to solve mathematical-logic problems) when the amount of video guide-based help intervention is varied?

2. What relationship does the amount of help requested have to achievement?

3. Does proactive, digital video guide-based help increase the likelihood that undergraduate students will request help more often?

4. Is there a significant difference between undergraduate students with varying locus-of-control indices in their ability to solve mathematical-logic problems when the type of video guide-based help intervention is varied?

5. Is there a significant difference in achievement due to an interaction effect of locus-of-control orientation and the type of video guide-based help intervention?

6. Is there a significant difference in achievement between students with varying computer experience when the type of video guide-based help intervention is varied?

7. Is there a significant difference in achievement due to an interaction effect between type of video guide-based help intervention and prior computer experience?

8. Is there a significant difference in achievement when the type of video guide-based help intervention is varied due to an interaction effect of locus of control orientation and prior computer experience?

9. Is there a significant difference in undergraduate students' preference towards proactive help due to their estimation of their own problem-solving ability?

10. Is there a significant difference in undergraduate students' preference towards proactive video guide help based on their estimation of the difficulty of problems presented to them?

11. Is there a significant difference in preference towards proactive video guide help due to the interaction between an estimation of their own problem-solving ability and their estimation of the difficulty of problems presented to them?

12. Are there significant differences in preference toward type of video guide-based help intervention due to the effects of their locus-of-control orientation, prior computer experience, and/or the interaction between locus of control and experience?

13. Are there significant differences in the expressed enjoyment of the problem-solving activity based on the effects of locus of control orientation, prior computer experience, perception of problem-solving ability, perception of the problem's difficulty, and/or the delivery system's proactive help status?

14. Are there significant differences in perceived usefulness of video guide help based on the effects of locus of control orientation, experience, perception of problem-solving ability, perception of the problem's difficulty, and/or the delivery system's proactive help status?

Limitations of the Study

This study contained limitations that affect the generalizability of the results. This study was conducted with undergraduate students enrolled in an instructional computing course designed for education majors. Enrollment in the course is not limited to education majors but is a required course for elementary education majors. Only those students who consented to participate were included.

The problem-solving activity at the core of this study, although designed and developed locally, has several characteristics in common with Mastermind™, a commercial game with widespread availability. Subjects familiar with this game, or games similar to it, would have an advantage over subjects who had never encountered such a game and, therefore, might need to rely less on the help features under consideration. Also, since the subjects were studying instructional computing, a professional interest in the activity might have been invoked by the treatment. The results of this study are generalizable to situations involving similar stimuli and classes of variables.

Definition of Terms

Agent as the term applies to computing can be defined as a character, enacted by the computer, who acts on behalf of the user in a virtual (computer-based) environment" (Laurel, 1990, p. 356). The idea of an agent was first conceived by John McCarthy of M.I.T. in the mid-1950s. The term "agent" was coined a few years later by Oliver G. Selfridge (Kay, 1984).

Guide will be used in this study to mean a domain-specific agent whose abilities will be confined to providing context-sensitive help to a user. The "guide" metaphor originally emerged as a travel "agent" in the process of designing an interface for an educational Hypermedia database (Oren, Salomon, & Kreitman, 1990). The guide used in this study is animated (digitized video) and speaks to the user. Although they are available upon request, they may also provide unsolicited information. That is, they may be "proactive."

Heuristic will be used to mean a general suggestion or strategy, independent of any particular topic or subject matter, that helps problem solvers approach and understand a problem and efficiently marshal their resources to solve it (Schoenfeld, 1980).

Human-Computer Interaction (HCI) is an interdisciplinary area of applied research and design practice. Its key concern is to understand and facilitate the creation of "user interfaces," that is, of computers as experienced and manipulated by human users (Carroll, 1991, p. 1).

On-line help is a user support structure provided by a computer providing information related to the task at hand or the program being used. It may or may not be context sensitive and its design is usually handled by the creators of the application program.

Locus of Control (LOC) is a construct which comes from social learning theory. It refers to a person's perceptions of the agency of control of the reinforcement he/she receives. One is said to have an internal locus of control if one feels that the reinforcements one receives occur primarily because of his/her own purposeful behavior. One is said to have an external locus of control if one feels that the reinforcements one receives occur primarily because of forces beyond the individual's control (Butterfield, 1964.)

Mediated Learning Experiences (MLE) are interactions during which the human organism is subject to the intervention of a mediator. Learners can benefit not only from the direct exposure to a particular stimulus, but they can also forge in themselves a repertoire of dispositions, propensities, orientations (e.g., locus of control), attitudes, and techniques that enable them to modify themselves in relation to other stimuli (Fuerstein, 1990, p. 75).

Video guide is used to mean a digital video representation of a guide as mentioned above. The digital video was created by "digitizing" an analog video recorded in a video studio, using a live performer acting as the guide.

Summary

The field of instructional technology is evolving rapidly and now represents a convergence of theories from the fields of information science, contemporary psychology, human-computer interaction, computer science, media, and the traditional disciplines associated with the field of education. This chapter presents a description of the problem, a need for the study, an overview of related literature, a list of research questions addressed by the study, selected definitions, and limitations and delimitations of the study.

Chapter 2 contains a review of literature that bears on questions investigated in the study. It focuses on two domains of machine-mediated learning as they relate to on-line help and guide-based help in particular, and on social learning theory, for example, locus of control orientation as a mediating variable. A description of the intervention tool and the design of the study appears in Chapter 3. Chapter 4 presents the findings of the study. Chapter 5 discusses the findings, their implications for instructional design, and recommendations for future research.

CHAPTER 2
REVIEW OF THE RELATED LITERATURE

Cognitive Artifacts

The interface between the computer and a human user illustrates a dovetail of direct information and representational information. Don Norman (1988) has suggested that human-computer interfaces *enable* and *represent*. In other words, the computer and the user both have a role in the task at hand. As Norman (1991) has noted, putting computers or other "cognitive artifacts" between a human and a task does not actually change the individual's capabilities, instead it changes the nature of the task performed by the person. Duffy, Mehlenbacher, and Palmer (1989, p. 367) argue that in such task-artifact scenarios it is necessary to understand (a) how the user accomplishes tasks with the artifact, (b) how the user deals with breakdowns in task performance, and (c) how the help system can get the user back on track. Users will not try to access performance-related information as long as the task is proceeding smoothly. Winograd and Flores (1986) have noted, however, that all users have breakdowns in which they lack either the machine source procedural information or domain specific semantic information to further the task.

Theories Related to the Task-Artifact Cycle

Beyond descriptions of how well performance-oriented systems support user actions and user evaluation, many theories exist to explain how users accommodate and interpret system feedback.

Attention

When a goal-directed activity breaks down, users are thrust into a secondary level of problem solving. Users must diagnose the problem, determine its implications, and attempt to solve it. The solution may depend on many factors including requisite knowledge, design of the artifact, and available information sources (Duffy et al., 1989; Norman, 1991). Many researchers (Bodker, 1989; Norman, 1991; VanLehn, 1990) have addressed this impasse or breakdown in the activity cycle. At such a breakdown, the user's attention switches to the impasse or, in Norman's terms, the gulf of evaluation. Although attention was formerly viewed as having limited quantitative capacity (Moray, 1967, referenced in Eberts & Eberts,1989; Kahneman, 1973), some later theories (e.g., McLeod, 1977; Navon & Gopher, 1979) accommodate the processing of information from several sources, often referred to as "resource pools," thereby allowing multiple responses. Wickens (1980) developed a model for processing resources that contains three dimensions. Each of the dimensions draws upon specific resource pools: stage-defined resource pools (early and late processes), modality-defined resource pools (auditory and visual encoding), and processing-defined resource pools (spatial and verbal processes). The stage-defined dimension allows the encoding or processing of information simultaneously with responses to previous information. The modality-defined dimension contains resource pools for simultaneous visual and auditory signal processing. The processing-defined pools represent spatial, graphic information and verbal, textual forms (Eberts & Eberts, 1989). According to Wickens (1980) and Wickens, Sandry, and Vidulich (1983), users are less likely to be overloaded if information is presented or time-shared from both pools in a dimension. Other researchers (McLeod, 1977; Robinson, Base, & Eberts, 1985) have validated predictions based on Wickens' synthesized structure for processing resources.

Building Mental Models and the Design of Production Systems

Problem-solving skills and inquiry strategies were the focus of several studies in the early 1970s. Robinson, Tickle, and Brison (1972) developed a basic problem-solving model based on a linear progression through the following steps: (a) identifying a question, (b) identifying possible alternative answers or avenues of inquiry that will produce an answer, (c) finding information about the alternatives, (d) adding up or synthesizing this information in some way, and (d) choosing an alternative.

Human Problem Solving (1972) by Newell and Simon dealt with many aspects of problem solving and stimulated research in computer-related activities. Theories presented in the book were based on the authors' earlier work involving problem-solving techniques or "information processes" (Newell, Simon, & Shaw, 1958), computer programs called Logic Theorist

(Newell et al., 1958), and The General Problem Solver (Ernst & Newell, 1969) and correlations between human and computer concept acquisition (Simon & Kotovsky, 1963). Many early computer-related studies dealt with error correction and semantic manipulations (Coombs & Alty, 1984). These studies examined the use of sentence tokens, sign and symbol use in specific behavioral contexts, and interpretation of expressions (Cresswell, 1973; Morris, 1971; Montague, 1972, respectively, cited in Jackson & Lefrere, 1984).

As these studies proliferated, researchers attempted to develop a theory of cognition which accommodated semantics, interpretation, and appropriateness in the man-machine interface (Bartsch, 1979; Kasher, 1977; Moran, 1981). This type of analysis was expanded by theorists Jackson and Lefrere (1984) to accommodate plan-based engineering of human-computer systems. According to Jackson and Lefrere (1984), there are four aspects of planning relevant to man-machine interaction:

> (1) provide planning aids for the user at the formation stage, (2) recognize the user's plan as an instantiation of one of its plan schemas, (3) revise its own hypothesis about the user's plan (should it turn out to be false) and help the user revise his plan (should it fail) and (4) promote the generalization of plans which succeed. These desiderata are easy to state, but difficult to engineer. (p. 71)

Systems based on plan-based theories require self-regulating facilities which must necessarily make decisions about user intentions, that is, the system must manipulate the representation of the problem space in ways that support the user. This manipulation has been referred to as a base-level action (Genesereth, 1983). According to Genesereth, choosing and sequencing base-level actions are meta-level actions that are performed by a system component called the meta-level interpreter. In other words, a highly organized system is supporting a user with a highly organized plan involved in a multi-leveled problem-solving scenario.

Highly organized system models play well in instructional design circles, and several instructional designers (Jones & Wipond, 1988; Merrill, 1987; Pirolli & Russell, 1990) have developed intelligent tutoring systems based on complex instructional models. Conceptual Systems Theory developed by David Hunt and associates is an example of an area of research based primarily on the structure of a learner's cognitive complexity rather than the content of personality development (Joyce, 1980, p. 19). In order to delineate the structure of these complex models, many researchers have developed sophisticated schematic representations. Anderson's (1988) review of intelligent tutoring systems discusses methods of representing declarative knowledge, procedural knowledge, and qualitative process models symbolically in order to promote desirable learning outcomes better.

Newell and Simon (1972) proposed the idea of a production system as a model of the human information system. Production systems have provided an almost generic theoretical formalism in cognitive psychology (Polson, 1987). Card, Moran, and Newell (1983) formalized the GOMS model: goals, operations, methods, and selection rules in order to analyze a learner's "how-to do-it" knowledge. In the GOMS model, goals are organized into collections of interrelated goals which are manipulated by control structures such as do-until loops. Goals represent user intentions; operations are triggered by users' basic physical actions; methods are composed of sequential operations necessary to achieve a subgoal; and selection rules are problem-solving fragments which specify when to apply a given method. Card, Moran, and Newell (1983) applied the GOMS model to the task of manuscript editing. The task was decomposed into a series of unit tasks, subgoals, methods, and submethods. It is important to emphasize that a user's how-to-do-it knowledge is a mixture of *task-specific* and *interface-specific* information (Polson, 1987).

Kieras and Polson (1985) developed a more elaborate production system model involving rules, working memory, and an interpreter. Rules are specified by a condition-action pair of the form IF (condition) THEN (action). The working memory contains representation of current goals, notes about current activities, and the external environment. The interpreter operates in cycles alternating between *recognize* and *act* modes (Polson, 1987).

Although instructional designers and other researchers continue to develop complex symbolic representations of learner development, transfer and productivity, questions concerning the validity of complex interpretations of production-system activity are common in the literature. A production-system model generates a hypothetical series of cognitive operations and the sequence of user actions required to complete the task. Upon making the assumptions necessary for representation of the user's knowledge, researchers derive learning and performance predictions (Polson, 1987). Pea (1988), however, argues that

> the productions in production systems modeling human thought or the nodes in knowledge representation networks in cognitive simulations are part of the *theorist's* construction of the problem situation. The question is begged because the problem solving is interpreted, not an experimental variable defined invariantly across subjects. (p. 181)

In their seminal work Human Problem Solving, Newell and Simon (1972) warned of putting too much emphasis on interpretation:

> The study of learning takes its cue from the nature of the performance system. If performance is not well understood, it is somewhat premature to study learning. . . . It is our judgement that in the present state of the art, the study of performance must be given precedence, even if the strategy is not costless. (p. 7)

The difficulty in developing mental models for users of technology is emphasized by Norman's (1983) findings. In observations of calculator users, Norman found rather than following a sophisticated plan, user's mental models were incomplete, unstable, unscientific, and parsimonious. For example, Norman found that participants often wrote down intermediary steps instead of using the calculator's memory and that they pressed the clear key several times when a single keypress achieved the desired outcome. Elsewhere, Norman (1984) summarizes, "What matters is how real users actually perform, not what designers believe the ideal user is capable of doing" (p. 14).

Carrol and McKendree (1987) agree that “there is little research evidence to support mental models of complex task domains and virtually no direct behavioral research either informs claims about psychological pertinence or has been brought to bear on evaluating these claims” (p. 17).

Whiteside and Wilson (1987) insist that designers should assume that users do not start with goals:

> The user’s goals are assumed to precede behavior, to have clear conditions of satisfaction, to be interpretable outside of the larger context of the user’s situation, to be organized in a strict hierarchy, and not to undergo radical, moment-to-moment transformation. . . . [This] does not capture what we observe in the field or lab, in our studies and observations of users. . . . Users are often unable to state unambiguous conditions of satisfaction, and are dependent on the context in which they are operating. To the extent that we can identify the users’ goals at any time, they are not organized in any strict hierarchy and are radically transformed as events unfold. (p. 359)

Help Intervention

Modern computerized help facilities are based in part on the formalization of the terse, cryptic error messages common in the early days of the personal computer (Brown, 1983). Error messages, unlike help messages, are generated only when an error state has been reached (Bosser, 1987). Shneiderman’s (1982) efforts brought a set of informal guidelines for error messages to the areas of programming and word processing. In addition, early work in advice-giving systems (Alty & Coombs, 1981) and varying approaches to help intervention (Fischer, Lemke, & Schwab, 1985) studied user behavior and the effects of concise help messaging.

John Waterworth (1984) developed a model for interaction as conversation based on the work of Bunt, Leopold, Muller, and van Katwijk (cited in Waterworth, 1984) who drew a distinction "between two types of *dialogue acts*: goal-oriented acts and dialogue-control acts. The former involve the direct communication of goal-relevant information between system and user; the latter are implicated in the prevention and correction of mistakes" (p. 231). Waterworth's model expands this distinction into three types of dialogue acts: goal-oriented acts, dialogue-control acts, and other acts. Goal-oriented acts compose the main body of the task-related dialogue, while dialogue-control acts include: confirmation, recovery/repair, help safety Net, extra guidance, stop information, restart/repeat, and exit. Other dialogue acts include the prologue and epilogue to the task at hand. The present study applied this model with respect to interaction.

Vygotsky (1978) uses the term Zone of Proximal Development to describe steps or levels of understanding which can be encouraged to maturity by the timely presentation of informative material which confirms, clarifies, or relates to what the individual already understands. The present study attempts to take advantage of the user's immediate experience by providing concise, informative feedback which is sensitive to situational context. According to Waterworth (1984), "Because of the temporary nature of speech, and the limitations of human memory, information must be presented in small enough 'packets' to be easily assimilated and acted upon by the user" (p. 234). Long, complete dialogue has been avoided in favor of small, suggestive fragments. The design, thereby, affords the user what Andrea diSessa (1986) has termed a "continuous incremental advantage" (p.1 38). According to diSessa, "The importance of the principle is not only having small steps in learning, and motivation for those steps, but so that at each stage the learner gets structured feedback on competent performance, feedback in terms of understanding goals" (p.139). Similarly, researchers Knox, Bailey, and Lynch (1989) discovered the need for what they call the "sequential disclosure" technique in interface design. "This technique was developed as we found that complete answers to subject queries often obscured the identification of key design features which could enable insight on the part of the subject" (p. 284).

Norman (1984) has said,

> Just as we have no need for an "error message" in conversation there should be no such thing as an "error message" in computer interaction. Rather, each utterance should be thought of as another iteration toward the goal, and if it is incompletely formed, ambiguous, or uninterpretable, nonetheless it represents an honest attempt toward the goal. Feedback, comments, and offers of assistance, yes; error messages, no. Recognition of this point of view changes the nature of the dialogue considerably. (p. 13)

Schoen (1982) notes,

> When the practitioner tries to solve the problem he has set, he seeks both to understand the situation and to change it. . . . Through the unintended effects of action, the situation talks back. The practitioner, reflecting on this back-talk, may find new meaning in the situation which leads him to new reframing. Thus

> he judges a problem-setting by the quality and direction of the reflective conversation to which it leads. (pp. 134-135)

An important feature of modern computer-based interfaces is the ability of one part of the user-machine dialogue to refer to another. Draper (1986) refers to this ability as *inter-referential I/O* and argues that it is the aspect of human conversation which allows us to cross the gap between monologue and dialogue. In man-machine dialogues, the machine does not originate communication but simply translates actions by user and system into changes to the display and maintains the necessary records for interpreting later references (p. 347). The interface is then able to enter the domain of discourse between the user and the system. The present study involves the application of inter-referential techniques with respect to help intervention.

Draper (1986) argues that a change in appearance in the interface may not only "alter the total size and amount of information displayed, but also its nature--that is, to present an alternative perspective on the same object" (p. 343). Gombrich (1974) agrees,

> The easier it is to separate the code from the content, the more we can rely on the image to communicate a particular kind of information. A selective code that is understood to be a code enables the maker of the image to filter out certain kinds of information and to encode only those features that are of interest to the recipient. Hence a selective representation that indicates its own principles of selection will be more informative than the replica. (p. 254)

The system under study uses a digitized video guide in an otherwise static graphic environment.

Proactive Help: User-Initiated vs. System-Initiated Help

Modern computer systems provide the tools required to measure user activity both temporally and functionally. In addition to allowing for sophisticated reporting of user activity, this feature allows the help facilities to become pro-active. Draper (1986) suggests, "Another important technique is that of autodisplay-of displaying output automatically without specific user request. . . . Communication takes place by user and system alternately modifying and referring to the objects on the screen" (p.347). System-initiated (autodisplayed) help is central to the current study.

Cohil and Williges (1982) compared user-initiated help to system-initiated help in a text-editing task scenario. It was found that the best performance was achieved with user-initiated help which referred to off-line documentation.

Miyata and Norman (1986) have developed a set of guidelines to be applied to interrupt-driven activities and system messaging: "It is clear that an interrupting message should not be presented in the stages of execution or perception, stages where the user is directly interacting with the system. . . . A good procedure might be to present relatively unobtrusive reminders to the user just following the completion of an action" (p. 278). The model used in the present study relates procedural messages immediately following an inappropriate action.

Locus of Control

Since the first locus-of-control scale was developed by Rotter in 1966, locus-of-control scales have been developed by several researchers (Goodman & Waters, 1987). The original scale developed by Rotter was enhanced by Reid and Ware in 1974 to measure three dimensions of locus of control: fatalism, social systems, and self control. Alternatively, in 1974 Levenson developed the three locus-of-control dimensions: chance, powerful others, and internal. Nowicki and Strickland developed a locus-of-control scale for children in 1973 using a fifth-grade reading level and later modified the scale for adults (Lefcourt, 1976).

Rotter (quoted in Louie, Luick, & Louie,1986) explains,

> When a reinforcement is perceived by the subject as following some action of his own but not being entirely contingent upon his action, then, in our culture, it is typically perceived as the result of luck, chance, fate, as under the control of powerful others, or as unpredictable because of the great complexity of the forces surrounding him. When the event is interpreted in this way by an individual, we have labeled this a belief in external control. If the person perceives that the event is contingent upon his own behavior or his own relatively permanent characteristics, we have termed this a belief in internal control. (p. 102)

The first study linking locus of control and cognitive activity was conducted by Seeman and Evans in 1962 (Lefcourt, 1976). These researchers determined that internals seek out information even if it has negative connotations for themselves. Seemam (1963, cited in Lefcourt, 1976) tested these assertions and concluded that an individual's sense of powerlessness governs his attention and acquisition processes.

Several educational researchers have studied relationships between locus of control and the style of instruction (Shadbolt, 1978). Leith (1973) argued that there was a relationship between teaching strategy and the extrovert-introvert dimension of personality, where extroverts achieved higher scores on a criterion measure after following an unstructured style of teaching, while introverts achieved higher success with a clearly structured style of teaching. According to Shadbolt (1978), "Perhaps the most difficult variable to evaluate is teaching strategy" (p. 227). The present study attempts to quantify the teaching strategy variable by computerized control of the guide-based intervention.

Coleman, Campbell, Hobson, McPartland, Mood, Weinfeld, and Work (cited in Louie, Luick, & Louie, 1986, p. 104) studied almost half a million school children across the United States and found that a belief of destiny was a major factor in school achievement.

According to Prawat, Grissom, and Parish (1979), persons who attribute their success or failure to fate, chance, or other people are designated as "externals"; "internals," on the other hand are people who accept personal responsibility for what happens to them. In a study of 499 students in grades 3-12, the researchers found that females were more internally controlled than males, with a dramatic decrease in externality noted in the middle school group (both males and females). A further decrease in externality was found in the high school group. Wildstein (1982) applied the same locus-of-control measure (the Children's

Nowicki-Strickland instrument) to 144 children and found that internals scored significantly higher on verbal problem-solving measures than externals but found no sex differences.

Butterfield (1964) found that frustration reactions become less constructive as locus of control becomes more external and that intropunitive reactions become more frequent as locus of control becomes more external. Interestingly, Butterfield found no relationship between locus of control and extrapunitive reactions. Butterfield also studied anxiety reactions with respect to locus of control and found that debilitating anxiety reactions increased and facilitating anxiety reactions decreased as locus of control became more external. In other words, the more the subject felt control over what happened, the more likely the subject's anxiety response would be a facilitative one. Conversely, the less control the subject felt, the more debilitating the anxiety response.

In a study of university undergraduates, Johnson and Kilmann (1975) found that internally rated students rated themselves as more confident of problem-solving abilities than did external rated students.

User Experience and the Interface

Martin's (cited in Ambardar, 1984) insistence on matching user-interface characteristics with those of the user was widely accepted in the HCI community. As Ambardar (1984) noted, however, "almost without exception, the only user characteristic that has been systematically co-varied with interface design is what might generally be termed 'training' " (p. 207). This work has led, for example, to the well-known recommendation that "novices" generally required "constrained" designs such as menu-based interfaces while "expert" users (i.e., trained) require more flexible approaches (Ambardar, 1984). The tendency to focus on "expert" behavior has been criticized by Bannon and Bodker (1991) who caution against concentrating on aspects of people that seem amenable to a computational metaphor. Bannon and Bodker contend that these aspects cannot be meaningfully detached from real situations of human activity to which they apply "activity theory."

Bannon and Bodker's claim not withstanding, several studies have involved specific claims about the pertinence of previous computer experience. Draper (1986) noted that experienced users often possessed special skills: "Their expertise lies, not in their having learned enough to solve any problem immediately, but in their having become skilled in gathering information and supplementing what they know" (p. 354).

Shneiderman (1987) divides user knowledge into syntactic and semantic domains. Syntactic knowledge contains device-dependent details. According to Shneiderman, users are much more troubled by syntactic irregularities in a system. Semantic knowledge forms an hierarchical structure of computer concepts and task concepts. Semantic knowledge must be acquired but is thought to be fairly stable in memory. As an example, Shneiderman cites attributes of a computer file such as size, name, and storage location. Although these concepts were once known to only a small number of computer scientists, they are now taught in elementary school.

Similarly, Hammond and Barnard (1984) classify knowledge required in system learning into two domains, primary and secondary. Primary knowledge is inferred from the nature of the demands of the task and the system and is required for successful use of the system. Primary knowledge consists of knowledge of the computer version of the domain, knowledge of the problem, knowledge of system operations, knowledge of physical interface, and knowledge of interface dialogue. Secondary knowledge sources are called upon to infer primary knowledge which is lacking or uncertain. Secondary knowledge (either interference or facilitation) consists of knowledge of the domain, knowledge of the workbase version of the domain (card catalog, etc.), knowledge of natural language, and knowledge of other machines and procedures.

CHAPTER 3
METHODOLOGY

This study is designed to determine whether proactive, computerized guide-based help intervention in a problem space can be more effective than on-demand help intervention only with users having varying experience and varying locus of control indices. Specifically, the treatments present mediated learning experiences (MLE), alternatively offered as on-demand guide assistance or proactive, system-initiated guide assistance to participants actively involved in a problem space. In addition, the study seeks to determine whether proactive guide-based help is perceived by the user as being more useful and more enjoyable.

Research Design

A split-plot repeated measures design was used in the study. Each group received both proactive and nonproactive digital video guide assistance during problem-solving activities. Subjects were randomly assigned to receive a given type of digital video guide assistance during the first problem scenario. During the second problem scenario the type of assistance each subject received was switched.

Regression analyses were performed on the data in this study. Depending on the nature of the particular variables used in an analysis, either multiple regression or logistic regression models were used. When appropriate, a standard analysis of variance was used. An analysis of variance (ANOVA) partitions the total variation of a sample into components and tests that the means are equal. The components, between group variance and within group (error) variance, are used to compute an F ratio that evaluates the effectiveness of the model. An ANOVA is used when the measurement level of the variable in question is either nominal or ordinal and the response is interval (Sall, Ng, & Hecht, 1991).

The use of multiple regression is increasing primarily because of its versatility and precision but also because of its application to data representing any scale of measurement (Gay, 1992). In standard regression analysis, the mean of the dependent variable is modeled. When the dependent variable is dichotomous, the proportion of responses in one of the categorical variables to the interval independent variables is modeled in a logistic regression (Agresti & Finlay, 1986), that is, logistic regression models how the proportion of responses in one of two categories depends on independent variables. When calculating the effect of a variable, it is necessary to calculate the probability that a randomly selected subject chooses one of the dichotomous responses. Since the probability (π) of such an event is linear for a single independent variable, it is possible to generate probabilities below 0 or above 1 for extreme values of X. This condition is illustrated in Figure 3-1. Rather than straight lines, logistic regression models use more realistic S-curves, also shown in Figure 3-1, thus insuring that probabilities always fall between zero and one.

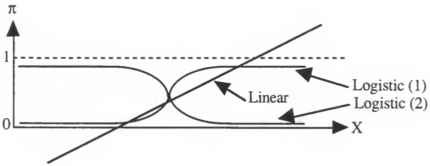


Figure 3-1. Linear and Logistic Regression Models for a (0,1) Response Source: Agresti & Finlay (1986, p. 483).

Nominal logistic regression is an estimation of the probability of choosing one of the response levels as a smooth function of the factor. Probabilities must be between 0 and 1 and sum to 1 across response levels for a given factor value (Hosmer and Lemeshow, 1989). The fitting principal for nominal logistic regression curves estimates maximum likelihood of fit which minimizes the sum of -log(P_i), where P_i is the probability attributed to the response that actually occurred. Therefore, -LogLikelihood statistics are reported for logistic regression models. Analysis of LogLikelihood tables correspond to Analysis of Variance tables for interval data, and -LogLikelihood for categorical data corresponds to Sums of Squares for interval data (SAS Institute, 1989). Likelihood-Ratio tests examine the likelihood that all parameters that make up an effect are zero (Sall, Ng, & Hecht, 1991).

Additional statistics reported for the regression models include the Rsquare statistic which is the proportion of total uncertainty which is attributed to the model fit. Rsquare values range from 0, which means that there is no gain by using the model over fixed background response rates, to 1, which indicates a perfect fit. High Rsquare statistics are rare in categorical models (SAS Institute, 1989). The chi-square statistic measures how well the categorical model fits the data, that is, it is a measure which tests the hypothesis that the model fits no better than fixed response rates across the whole sample. The Prob>ChiSq statistic, often referred to as the p-statistic, represents the probability of getting, by chance alone, a chi-square value greater than the one computed for the model.

Leverage plots are used to illustrate a given effect's significance. Effects tests in a logistic regression compare a model with and without the effect and see if the difference in the Loglikelihood is significant. Similarly, a leverage plot compares the sum of squared residuals of the model with the effect and with the effect removed. If residual errors are significantly smaller with the effect included, the effect has significantly contributed to the fit (SAS Institute, 1989). Graphically, the components of a general leverage plot are given in Figure 3-2. The mean line, represented by the horizontal line in the figure, represents a model with a constraint to zero on the hypothesized effect. Leverage plots use confidence

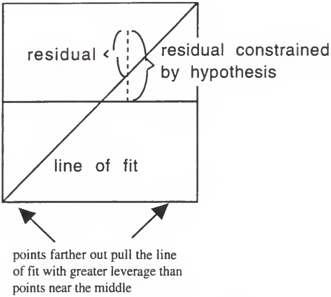

residual
residual constrained by hypothesis
line of fit
points farther out pull the line of fit with greater leverage than points near the middle

Figure 3-2. General Leverage Plot

Source: SAS Institute (1989, p. 323)

curves to indicate whether or not the test being run is significant. If the confidence curves cross the horizontal line, as shown in Figure 3-3, the model is significant.

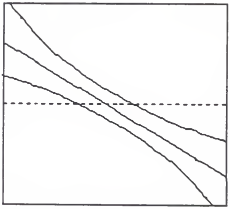


Figure 3-3. Confidence curves surrounding line of fit in a significant model

In this study, predictors for the analyses related to the win outcome criterion, that is, correct solution, were computer experience, score on the Nowicki-Strickland Locus of Control inventory, and the status of proactive, automatic digital video guide help. Activity functions used as predictors related to win outcome included amount of digital video help requested and the amount of digital video help received. In addition to the win outcome criterion, frequency of video help requests, preference toward proactive help, perceived help usefulness, and enjoyment of the activity were each held as criterion (response) variables. Interactions between predictor variables were also examined. In attitudinal analyses, perceived problem-solving ability and perceived problem difficulty level were also used as predictors.

Population

The population for this study consisted of college students enrolled in the undergraduate program at the University of Florida.

Sample

The sample for this study was drawn from Introduction to Instructional Computing Classes during three terms in 1993. The subjects were juniors and seniors. Prior to the study, the students were asked by their instructor if they were willing to participate in a study related to computers and learning. Immediately preceding the study, an explanation of the procedures used in the study was explained to the students. Students were randomly assigned to two experimental groups. A total of 114 students responded, and of these 105 students were included in the study. Computer failures and improper ID matches resulted in dropping nine partial sets of data.

Instruments

Three instruments were used in this study, two written instruments and one computerized instrument. The two written measures were the Nowicki-Strickland Locus of Control Inventory for Adults and an experience measure developed for the purpose of this study.

The Nowicki-Strickland Locus of Control Inventory for Adults consists of 40 yes-no questions. The adult version of the inventory was developed in response to the shortcomings of the Rotter (1966) Locus of Control Scale with respect to college and noncollege population generalizability (Nowicki & Duke, 1974). The test is keyed in an external direction, the total score being the number of external responses (Slayton, 1984). Thus, the higher the score, the more an external locus of control is indicated. The Nowicki Strickland test, from its format and item content, represents expectancy of competence, which is one aspect of the I-E continuum (Slayton, 1984).

The experience survey was created by the experimenter and based on a model used in an earlier computer-based study. The survey was designed to determine a level of familiarity with common software packages, research facilities, and operating systems as well as the participants' total previous computer use. The experience survey was graded according to the following criteria: (a) longevity of computer use, (b) frequency of computer use, (c) type of activities done on the computer, (d) software package familiarity, and (e) operating system familiarity. Participants were identified as experienced or nonexperienced according to a point scale rating. The survey was graded (a straightforward counting procedure) by the experimenter and two other people identified as having a strong background in computing and instruction. An inter-scorer reliability of .9915 existed.

In addition to the written measures, a computer program based on the Coin Challenge game developed by Dr. Elroy Bolduc was created by the researcher to determine if varying the type of help intervention given the student had an effect on game performance. As with Selz's productive thinking model, the activity is designed to give the user what Selz called a 'partial result' which must be examined and evaluated before a new knowledge complex can be assembled. Essentially, Coin Challenge puts the user into a problem space in which deductive logic can be applied for positive gain or task completion. The related help, then, must introduce the user to this metric. The help component deals with introducing the user to the functional requirements (i.e., rules and goals) by using a preliminary computerized slide presentation. Subsequently, the digital video guide help available in the problem space assists users in dealing with problem solving as well as functional misques or ambiguities (for more on this approach see Martin, 1988).

The computer activity, Coin Challenge, includes a problem scenario and two five-question surveys. The surveys are administered after the first and second problems. They incorporate a semantic differential scale (Osgood, Suci, & Tannenbaum, 1957), and subjects select values along the scale by clicking the mouse on the appropriate number. The questions on the survey are as follows:

How would you classify your computer expertise?

1. Use the computer for word processing or not at all.
3. Use the computer once in a while for various things.
5. Use the computer every day. Familiar with a lot of software.

How would you rate your problem-solving ability?

1. I have never been good at solving logic problems.
3. I consider myself an average problem solver.
5. I enjoy doing problem solving activities.

How would you rate the game's difficulty level?

1. It was extremely easy to learn and play.
3. It was fairly difficult to learn and play.
5. It was very difficult to learn and play.

Were the game's HELP features useful to you?

1. The help features were useless.
3. I used the help features occasionally.
5. I could not have played the game without the help features.

SET TWO:

In one game, help was automatic. In the other, you had to request help. Which do you prefer?

1. I want to request help. I hated the automatic help!
3. I don't really have an opinion, it doesn't affect the game.
5. I loved being given hints by the helper.

Did you enjoy playing the game?

1. No, I didn't like this game at all!
3. It was okay.
5. I liked this game a great deal.

If you were to play the game again, which type of help would you choose?

1. Automatic Help: I'd like the helper to make suggestions.
2. Requested Help Only: I want to ask for help when I need it.

Would you like to play again now?

1. Yes, I would.
2. No thanks.

Coin Challenge software was designed to keep an audit trace of all user activity in the problem space. From this trace, specific information about the activity can be extracted. In fact, the entire activity can be reconstructed with procedural and temporal precision. In addition, responses to the two five-question surveys were recorded, but not analyzed, by the computer program. The file which contained the audit trace and survey information for each participant was saved and collected by the experimenter immediately following the computer session.

Coin Challenge incorporates a digital video guide which is central to this experiment. The guide video was created in the video production studio of Norman Hall at the University of Florida. A local science instructor played the part of the guide. The researcher wrote a script for each message and mediation used in the study. The video (with audio track) was recorded using 1/2-half inch tape and then transferred to VHS tape. From this tape, the researcher captured specific video sequences digitally using a VideoSpigot™ capture board and a Macintosh™ Quadra 700 computer. The researcher then digitally edited the digital video files. Video sequences were captured at 15 frames per second in 256 color mode. The frame size for capture was set at 80 X160 pixels, or 1/12th of a 640 X 480 screen, which is currently a de facto standard. Finally, the researcher integrated the finished video segment files into the Coin Challenge program.

Stimuli

The problem-solving activity begins with a linear computerized slide presentation which includes the objective of the game, the directions, the tools available to the user, and the help facilities available. Graphics, animation, text, and sound are used in the presentation. The user may not interrupt the presentation, that is, each subject views the same instructions.

Upon completion of the instructions, the subject is asked for an I.D. number and the problem-solving activity begins. The user is presented with a screen or game board which has the following elements: a blank board on which to place coins, a change bank which is the source of coins, a reminder box which explains the meaning of the feedback mechanism (clues), an answer cover, and a Help Box. The game begins with a video guide appearing in the Help Box which says "Click Here for Help." A static picture of the guide then remains in the Help Box. In this study, the guide is a male figure wearing a bow tie and glasses, similar to the classic computerized agent "Phil" (Laurel, 1990).

The object of the game is to try to determine which four coins are hidden under the answers cover and their placement. In order to make this determination, the user is expected first to make a four-coin guess. This system then provides feedback consisting of how many coins are in exactly the correct position, how many coins are correct but in the wrong position, and by how many cents the guess is off. This feedback is given via indicator codes. Once the user has interpreted and evaluated this partial result, another more educated "guess" is made and evaluated by the system. A game consists of up to six such guesses/attempts or a win, whichever comes first.

Coins are randomly placed under the answers cover by the computer from a pool of Half-Dollar, Quarter, Dime, Nickel, Penny, and Blank Token. Rules of the game restrict the total value of the coins under the answers cover to 99 cents or less. Thus, the game resembles the Parker Brothers game Mastermind™ with the added dimension of coin value which introduces arithmetic into the game.

The help facilities in the program attempt to address the user's needs in several ways. Problem solving should be treated as a process (Kantowski 1980; Norman 1983; Polya 1962), and the help facilities of the program have been designed to provide informational, procedural, and strategic assistance. Coin Challenge is interactive and makes algorithmically intelligent decisions regarding the needs of the user. For example, early in the game, or if the user takes inappropriate actions, the program will issue procedural help rather than strategic help.

Two versions of the Coin Challenge were used with each subject. In one version, video guide help is automatic or proactive, occurring after specific periods of user inactivity, or when help is requested by the user. In the other, help must be requested by the user. This is accomplished by moving the mouse pointer to the help box and clicking the mouse button. The help messages given are the same in the two versions.

The distinctions in the stimuli for this experiment are thus centered around the nature of the help given to the user. First, it is necessary to offer assistance in some form to the user, and requested help is used as the baseline for this help. Second, the stimuli had to incorporate proactive or automatic help in order to measure its effect on the user.

Procedure

The written measures were administered in a supervised classroom setting to groups of approximately 15 participants. When the group completed the forms, they were ushered to a computer lab which had been set up with the Coin Challenge activity. The activity was created for Macintosh computers using HyperCard™ from Apple Computer. The laboratory was outfitted with Macintosh LCII computers, 13-inch Apple Color Monitors (640 by 480 resolution) with stereo headphones attached to each station. Every participant observed a computerized slide show of instructions which lasted approximately 3 minutes. The instructions appeared on each participants monitor and were noninterruptable. The instructions contained graphics, text, animation, and sound. After viewing the slide show, the participant was asked to enter the same I.D. used for the written dimension of the study. The Coin Challenge activity then began.

Each participant was expected to do the activity twice, with a third game optional. One-half of the participants received proactive help during the first game, while the other half received help only when they requested it. After the first game the participants were presented with an informal attitudinal survey composed of five questions (see Appendix C). A semantic differential scale (Osgood, Soci, & Tannenbaum, 1957) format was used for each question. Responses were made by simply clicking the mouse on the appropriate mark on the scale.

After responding to the five questions, the Coin Challenge was reentered. During this second game, the type of help was reversed. If proactive help was in effect during the first game, it was disabled so that users were required to request help in the second. Similarly, if it were necessary for the participant to request help in the first game, help was automatic in the second game.

After the second game, the participants were again asked to answer a five-question survey. The last question gives them the option of entering the activity a third and final time. The experimenter was present during the computer session to assist with technical difficulties, but no activity-related feedback was given to the participants by the experimenter. The experimenter also took notes on comments participants made during the activity.

Summary

The present study was designed to determine the effectiveness of proactive digital video guide-based assistance with users having varying experience and varying locus of control indices. The type of digital video guide assistance was varied to determine if proactive, automatic help affects a user's performance in a novel problem space. Although the frequency of help received varied depending on help status, the help received in both cases was the same, and context sensitive. A split-plot design was used in the study.

The subjects in this study were 105 juniors and seniors from the University of Florida who were enrolled in introductory instructional computing courses. Each subject was given an experience survey, a Nowicki-Strickland Locus of Control Inventory, and then participated in a computerized problem-solving activity. The problem-solving activity consisted of two interactive sessions in Coin Challenge, a logic- and arithmetic-based problem scenario, and a computerized attitude survey with questions being administered before and after the second Coin Challenge session. All subjects' actions in the computer portion of the study were recorded by the computer and saved for subsequent analyses.

CHAPTER 4
ANALYSIS OF THE DATA

This purpose of this study was to determine whether proactive, computerized guide-based help intervention in a problem space is more effective than on-demand help intervention alone with users classified as possessing a range of locus-of-control measures and experience. Specifically, the treatments present mediated learning experiences (MLE), alternatively offered as on-demand guide assistance or proactive, system-initiated guide assistance to participants actively involved in the problem space. In addition, the study seeks to determine what factors contribute to the user's perception of the video guide-based help.

Results

Multiple regression, logistic regression and analysis of variance techniques were used to analyze the data. Each of the hypotheses is stated in operational null form with the relevant statistics presented in summary tables. Graphs and leverage charts have been included for significant effects.

> Hypothesis 1: There is no significant difference in achievement when the amount of video guide-based help intervention is varied.

The logistic regression performed on the data yielded a p-statistic (Prob>Chi Square) of 0.0045 for the main effect of amount of video guide-based help intervention. Since this is significant at the p< .01 level, the null hypothesis was rejected. The summary of fit and parameter estimates are given in Table 4-1 and a graph of expected effects of total help received on win outcome is shown in Figure 4-1.

Table 4-1

The Effects of Total Help Received on Win Outcome

Rsquare (U)	0.078945
Observations (or Sum Wgts)	105

Analysis of LogLikelihood

Source	DF	–LogLikelihood	ChiSquare
Model	1	5.736267	11.47253
Error	103	66.925094	Prob>ChiSq
C Total	104	72.661361	0.000706

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-0.5487473	0.2858245	3.69	0.0549
Help Freq	0.07280954	0.0256197	8.08	0.0045

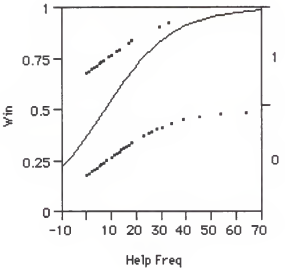


Figure 4-1. The Effects of Total Help Received on Win Outcome

Hypothesis 2: There is no significant difference in achievement when the frequency of user requests for help varies.

Logistic regression analyses were performed on the data. The model (Table 4-2) includes relevant data to test the hypotheses related to subject parameters and activity concerning locus of control orientation, level of experience, help type (manual or proactive), and frequency of requested help. A preliminary analysis yielded nonsignificant results for all interaction effects. The analysis of Log Likelihood which tests the model is shown in Table 4-2. The analysis resulted in a p-statistic of 0.002436 which is significant at the p<.01 level. However, the model exhibited a significant lack of fit (p=0.023001). A stepwise logistic regression was performed eliminating the locus of control variable which had produced an

Table 4-2

The Effects of Locus of Control, Experience, Help Status, and Requested Help Frequency on Win Outcome

Rsquare (U)	0.113419
Observations (or Sum Wgts)	105

Analysis of LogLikelihood

Source	DF	–LogLikelihood	ChiSquare
Model	4	8.241173	16.48235
Error	100	64.420188	Prob>ChiSq
C Total	104	72.661361	0.002436

Lack of Fit

Source	DF	–LogLikelihood	ChiSquare
Lack of Fit	94	61.647599	123.2952
Pure Error	6	2.772589	Prob>ChiSq
Total Error	100	64.420188	0.023001

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-1.4742017	0.7163256	4.24	0.0396
LOC	0.02606149	0.051617	0.25	0.6136
Experience	0.06618216	0.0423318	2.44	0.1180
Proactiv[0-1]	-0.4874518	0.2329204	4.38	0.0364
Requested Help	0.41296946	0.1422057	8.43	0.0037

insignificant effect. The resulting model is shown in Table 4-3. The model was based on the frequency of help requested during the activity, experience, and proactive help status and yielded a p-statistic of 0.001019 which is significant at the p<.01 level. The main effect test for help requested by the user, indicated by Requested Help in Table 4-3, was based on the frequency of help requests during the activity and yielded a p-statistic of 0.0039 which is significant at the p< .01 level. Therefore, the null hypothesis was rejected. Figure 4-2 illustrates the expected effect of requested help on win status based on the model in Table 4-3.

Table 4-3

The Effects of Experience, Proactive Help Status and Requested Help Frequency on Win Outcome

Rsquare (U)	0.111656
Observations (or Sum Wgts)	105

Analysis of LogLikelihood

Source	DF	–LogLikelihood	ChiSquare
Model	3	8.113044	16.22609
Error	101	64.548317	Prob>ChiSq
C Total	104	72.661361	0.001019

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-1.2289784	0.5214269	5.56	0.0184
Experience	0.06495216	0.0423236	2.36	0.1249
Proactive[0-1]	-0.4754479	0.2311267	4.23	0.0397
Requested Help	0.40914646	0.1417484	8.33	0.0039

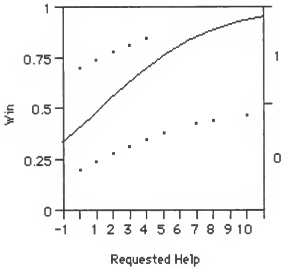


Figure 4-2. The Effect of Requested Help Frequency on Win Outcome

Hypothesis 3: There is no significant difference in the number of requests for help when the type (proactive or manual) of digital video guide assistance is varied.

The analysis of variance performed on the data resulted in an F statistic of 6.9021 (Table 4-4). Because this was significant at the p< .01 level, the null hypothesis was rejected. A leverage plot representing the contribution of proactive help status on frequency of help requests is shown in Figure 4-3.

Table 4-4

The Effect of Proactive Help Status on Frequency of Help Requests

Rsquare	0.062802
Root Mean Square Error	2.262601
Mean of Response	1.685714
Observations (or Sum Wgts)	105

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	35.33413	35.33416.9021	
Error	103	527.29444	5.1194Prob>F	
C Total	104	562.62857	0.0099	

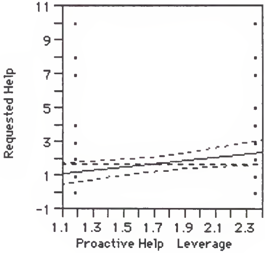


Figure 4-3. Leverage Chart for the Effect of Proactive Help Status on Requests for Help

> Hypothesis 4: There is no significant difference in achievement between students with varying locus of control indices when the type of video guide-based help intervention is varied.

The logistic regression analysis performed (Table 4-2) yielded a p-statistic which was not significant at the $p < .05$ level. Therefore, this null hypothesis could not be rejected.

> Hypothesis 5: There is no significant difference in student achievement due to an interaction effect of locus of control orientation and the type of video guide-based help intervention.

The logistic regression (Table 4-5) performed show no significant interaction between the locus-of-control orientation and the type of video guide-based help. Therefore, this null hypothesis was not rejected.

> Hypothesis 6: There is no significant difference in achievement between students with varying experience when the type of video guide-based help intervention is varied.

Because the regression performed on the data yielded p-statistics for the experience and help status effects which were not significant at the $p < .05$ level (Table 4-3), this null hypothesis could not be rejected.

Table 4-5

The Interaction Effects between Locus of Control, Experience, and Requested Help on Win Outcome

Rsquare (U)	0.117596
Observations (or Sum Wgts)	105

Analysis of LogLikelihood

Source	DF	–LogLikelihood	ChiSquare
Model	7	8.544710	17.08942
Error	97	64.116652	Prob>ChiSq
C Total	104	72.661361	0.016829

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-1.2957163	1.2607884	1.06	0.3041
LOC*Experience	0.00217536	0.0117674	0.03	0.8533
LOC*Proactiv[0-1]	0.01194278	0.054916	0.05	0.8278
Exp.*Proactiv[0-1]	0.03236701	0.0434285	0.56	0.4561

Hypothesis 7: There is no significant difference in achievement due to an interaction effect of type of video guide-based help intervention and experience.

The p-statistic for the interaction between video guide-based help intervention and experience obtained by performing a logistic regression on the data (Table 4-5) was not significant at the $p < .05$ level. Consequently, this null hypothesis was not rejected.

Hypothesis 8: There is no significant difference in achievement when the type of video guide-based help intervention is varied due to an interaction effect of locus of control orientation and experience.

The logistic regression analysis performed on the data (shown in Table 4-5) yielded no significant results for the interaction effect between locus of control orientation and experience. Therefore, the null hypothesis was not rejected.

Hypothesis 9: There is no significant difference in student preference towards proactive help due to an estimation of their own problem-solving ability.

The F ratio for problem-solving ability was 5.0153 at df=1 (Table 4-6). Because an F ratio of 5.0153 is significant at the $p<.05$ level, this null hypothesis was rejected. The leverage plot showing the contribution of perceived problem-solving ability on preference toward proactive digital video guide help is given in Figure 4-4.

Hypothesis 10: There is no significant difference in student preference towards proactive video guide help due to their estimation of the difficulty of problems presented to them.

The computed F ratio of 0.0011 (Table 4-6) is not significant at the $p<.05$ level. This null hypothesis was not rejected.

Table 4-6

The Effect of Perceived Problem Solving Ability on Preference Toward Proactive Digital Video Guide Help

Rsquare	0.0485
Root Mean Square Error	1.153474
Mean of Response	2.114286
Observations (or Sum Wgts)	105

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	2.8141897	0.47837	5.88	0.0000
P.Ablity	-0.230607	0.10297	-2.24	0.0273
DiffLev	0.004151	0.12673	0.03	0.9739

Source	Nparm	DF	Sum of Squares	F Ratio	Prob>F
P.Ablity	1	1	6.6728022	5.0153	0.0273
DiffLev	1	1	0.0014274	0.0011	0.9739

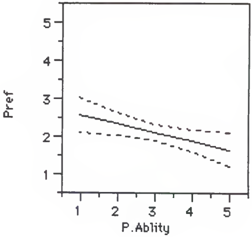


Figure 4-4. Effect of Perceived Problem Solving Ability on Preference Toward Proactive Digital Video Guide Help

> Hypothesis 11: There is no significant difference in student preference towards proactive video guide help due to an interaction between an estimation of their own problem-solving ability and their estimation of the difficulty of problems presented to them.

An analysis of variance was performed on the data. The F ratio for the interaction between estimation of problem-solving ability and estimation of problem difficulty was 0.0055 at df=1 is not significant at the $p < .05$ level. Consequently, this null hypothesis was not rejected.

> Hypothesis 12: There is no significant difference in student preference towards type of video guide due to the effects of their locus-of-control orientation, experience, and/or the interaction between locus of control and experience.

An analysis of variance was performed on the various effects in this model which examined preference toward proactive help. Significant effects at the $p < .05$ level were found for locus of control, experience, and the interaction between locus of control and experience (Table 4-7). However, since the model itself is not significant at the $p < .05$ level, the null hypothesis could not be rejected.

Table 4- 7

The Effect of Locus of Control, Experience, and the Interaction Between Locus of Control and Experience on Preference Towards Type of Video Guide-based Help Intervention

Rsquare	0.070314
Root Mean Square Error	1.145805
Mean of Response	2.114286
Observations (or Sum Wgts)	105

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.5700636	0.5792	0.98	0.3274
LOC	0.179198	0.06644	2.70	0.0082
Exp.	0.1102617	0.04664	2.36	0.0200
LOC*Exp.	-0.013017	0.0056	-2.32	0.0221

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	3	10.02873	3.34291	2.5463
Error	101	132.59984	1.31287	Prob>F
C Total	104	142.62857		0.0602

Hypothesis 13: There is no significant difference in students' expressed enjoyment of the problem-solving activity due to the effects of locus-of-control orientation, experience, perception of their own problem-solving ability, perception of the problem's difficulty and/or the delivery system's proactive help status.

A multiple regression was performed on the data which examined the effects of several parameters related to the interaction scenario (Table 4-8). A significant effect at the p< .05 level was found for locus-of-control orientation with an F ratio of 4.1276. The estimation of problem-solving ability also yielded a significant effect (p< .01) with a computed F ratio of 11.0524. Perceived difficulty level was also significant (p< .01) with an F ratio of 11.4151. In addition, the interaction between locus of control orientation and level of experience was significant at the p<.05 level. However, since the level of experience produced an F ratio of 1.76 and was not significant at p<.05, this null hypothesis was accepted.

> Hypothesis 14: There is no significant difference in students' perceived usefulness of video guide help due to the effects of locus-of-control orientation, experience, perception of their own problem-solving ability, perception of the problem's difficulty and/or the delivery system's proactive help status.

The multiple regression analysis performed on this model shows a significant effect for the main effects locus-of-control orientation and perceived problem-solving ability and for the interaction effects between locus of control and experience and the interaction between perceived problem-solving ability and perceived difficulty level. (Table 4-9). All other main effects and interactions were not significant at the p< .05 level. Consequently, this null hypothesis was not rejected.

Table 4-8

The Effect of Locus of Control, Experience, Perceived Problem Solving Capability, Perceived Problem Difficulty Level, and Related Interactions on Enjoyment of the Activity

Rsquare	0.235634
Root Mean Square Error	0.920375
Mean of Response	3.428571
Observations (or Sum Wgts)	105

Whole–Model Test
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	5	25.85236	5.17047	6.1038
Error	99	83.86192	0.84709	Prob>F
C Total	104	109.71429		0.0001

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	2.5675015	0.6124	4.19	0.0001
LOC	0.1093577	0.05383	2.03	0.0449
Exp.	0.0661365	0.03749	1.76	0.0808
LOC*Exp.	-0.009769	0.00452	-2.16	0.0329
P.Ablity	0.2813608	0.08463	3.32	0.0012
DiffLev	-0.342581	0.1014	-3.38	0.0010

Effect Test

Source	Nparm	DF	Sum of Squares	F Ratio	Prob>F
LOC	1	1	3.4964652	4.1276	0.0449
Exp.	1	1	2.6360329	3.1119	0.0808
LOC*Exp.	1	1	3.9651380	4.6809	0.0329
P.Ablity	1	1	9.3623821	11.0524	0.0012
DiffLev	1	1	9.6696095	11.4151	0.0010

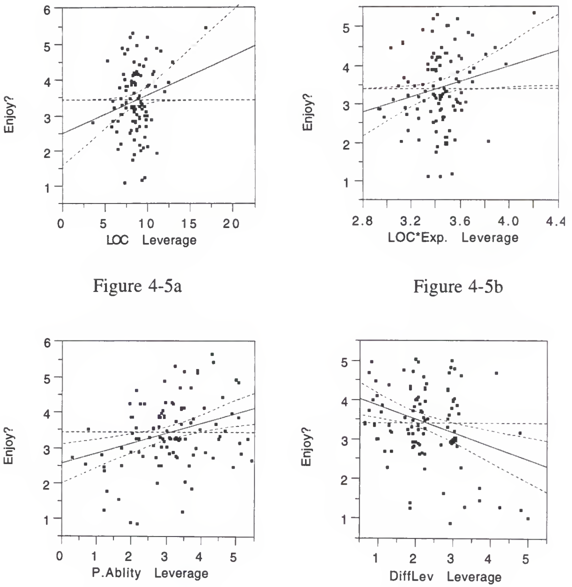


Figure 4-5a

Figure 4-5b

Figure 4-5c

Figure 4-5d

Figure 4-5. Factors Contributing to Enjoyment of the Problem-Solving Activity

a) Leverage Plot: The Effect of Locus of Control on Activity Enjoyment
b) Leverage Plot: The Effect of the Interaction Between Locus of Control and Experience on Activity Enjoyment
c) Leverage Plot: The Effect of Perceived Problem Solving Ability on Activity Enjoyment
d) Leverage Plot: The Effect of Perceived Difficulty Level on Activity Enjoyment

Table 4-9

The Effect of Locus of Control, Experience, Perceived Problem-Solving Capability, Perceived Problem Difficulty Level, and Related Interactions on Perceived Usefulness of Digital Video Guide Help

Rsquare	0.173846
Root Mean Square Error	0.971522
Mean of Response	2.352381
Observations (or Sum Wgts)	105

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	6	19.46418	3.24403	3.4370
Error	98	92.49772	0.94385	Prob>F
C Total	104	111.96190		0.0040

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	2.3074678	0.83825	2.75	0.0070
LOC	0.1619433	0.05692	2.85	0.0054
Exp.	0.0749348	0.03963	1.89	0.0616
LOC*Exp.	-0.011377	0.00477	-2.38	0.0191
P.Ablity	-0.512272	0.19774	-2.59	0.0110
DiffLev	-0.457606	0.26431	-1.73	0.0865
P.Ablity*DiffLev	0.2166131	0.08611	2.52	0.0135

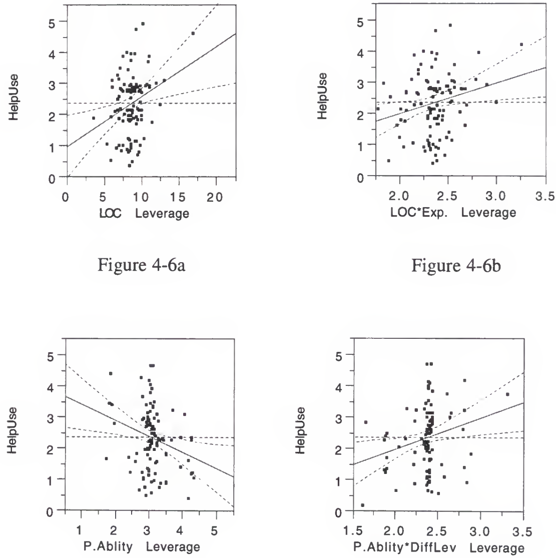


Figure 4-6a

Figure 4-6b

Figure 4-6c

Figure 4-6d

Figure 4-6. Factors Contributing to Perceived Usefulness of Digital Video Guide-based Help

a) Leverage Plot: The Effect of Locus of Control on Perceived Usefulness of Digital Video Guide Help
b) Leverage Plot: The Effect of the Interaction Between Locus of Control and Experience on Perceived Usefulness of Digital Video Guide Help
c) Leverage Plot: The Effect of Perceived Problem Solving Ability on Perceived Usefulness of Digital Video Guide Help
d) Leverage Plot: The Effect of the Interaction Between Perceived Difficulty Level and Perceived Difficulty Level on Perceived Usefulness of Digital Video Guide Help

Summary

The research questions addressed by this study fall into three categories designed to investigate the somewhat broader questions:

1. Does digital video guide-based help intervention support a user's efforts in a problem space?
2. Is the effectiveness of proactive digital video guide-based help affected by parameters such as locus of control and experience?
3. What factors contribute to the user's perception of the video guide-based help system?

The analyses of the data indicate that it is likely that more digital video guide-based help will lead to more success in solving the problem correctly, and requesting such digital video guide-based assistance will also have a positive effect on problem-solving ability. Experience and locus of control are not significantly related to the problem-solving achievement when the type of digital video help is varied and neither is the interaction between experience and locus of control.

Students who perceive themselves as good problem solvers are less likely to prefer proactive, automatic digital video help. Similarly, students with a higher locus of control index and those who consider themselves good problem solvers enjoyed the game to a significantly greater extent. As might be expected, the more difficult the problem is perceived to be, the less likely the student is to enjoy the activity. Students who were rated as more external in locus-of-control orientation perceived the digital video guide as more helpful. Students considering themselves good problem solvers found digital video guide assistance less useful. There was also a significant interaction between locus of control and experience in the subjects' perception of the usefulness of digital video guide assistance.

CHAPTER 5
DISCUSSION AND CONCLUSION

Introduction

The research questions addressed by this study were designed to examine various aspects of rapidly growing concern in the area of human-computer interaction. The study focuses on a digital video guide which is used to offer advice to users actively involved in a problem space. Using guides to assist users in computer-related activities is a relatively recent phenomenon. This study, therefore, examined the effects of its principal foci, user characteristics related to experience and locus of control, and also surveyed users as to their preferences toward the help system incorporated in the study.

The study investigated the broad questions:

1. Does digital video guide-based help intervention support a user's efforts in a problem space?

2. Is the effectiveness of proactive digital video guide-based help affected by parameters such as locus of control and experience?

3. What factors contribute to the user's perception of the video guide-based help system? The first question deals with the appropriateness of a digital video guide representation as a help facility. Norman (1993) writes,

"Bad representations turn problems into reflective challenges. Good representations can often transform the same problems into easy experiential tasks" (p. 55). The second question relates to the digital video guide's appropriateness for the person, that is, does it enhance the person's ability to interpret the problem. Specifically, this study examined whether user characteristics such as locus of control index and experience related to success in the problem space given a particular type of digital video help. Finally, the third question is directed toward the appropriateness of the proactive digital video guide to the task at hand. Did the users perceive beneficial or relevant consequences to using the help facilities in the problem space based on the proactive status of the digital video system help?

Findings

> Hypothesis 1: There is no significant difference in achievement when the amount of video guide-based help intervention is varied.

The null hypothesis was rejected.

> Hypothesis 2: There is no significant difference in achievement when the frequency of user requests for help varies.

The null hypothesis was rejected.

Hypothesis 3: There is no significant difference in the number of requests for help when the type (proactive or manual) of digital video guide assistance is varied.

The null hypothesis was rejected.

Hypothesis 4: There is no significant difference in achievement between students with varying locus of control indices when the type of video guide-based help intervention is varied.

The null hypothesis was not rejected.

Hypothesis 5: There is no significant difference in student achievement due to an interaction effect of locus-of-control orientation and the type of video guide-based help intervention.

The null hypothesis was not rejected.

Hypothesis 6: There is no significant difference in achievement between students with varying experience when the type of video guide-based help intervention is varied.

The null hypothesis was not rejected.

Hypothesis 7: There is no significant difference in achievement due to an interaction effect of type of video guide-based help intervention and experience.

The null hypothesis was not rejected.

Hypothesis 8: There is no significant difference in achievement when the type of video guide-based help intervention is varied due to an interaction effect of locus of control orientation and experience.

The null hypothesis was not rejected.

Hypothesis 9: There is no significant difference in student preference towards proactive help due to an estimation of their own problem-solving ability.

The null hypothesis was rejected.

Hypothesis 10: There is no significant difference in student preference towards proactive video guide help due to their estimation of the difficulty of problems presented to them.

The null hypothesis was not rejected.

Hypothesis 11: There is no significant difference in student preference towards proactive video guide help due to an interaction between an estimation of their own problem-solving ability and their estimation of the difficulty of problems presented to them.

The null hypothesis was not rejected.

Hypothesis 12: There is no significant difference in student preference towards type of video guide due to the effects of their locus-of-control orientation, experience, and/or the interaction between locus of control and experience.

The null hypothesis was not rejected.

> Hypothesis 13: There is no significant difference in students' expressed enjoyment of the problem-solving activity due to the effects of their locus-of-control orientation, experience, perception of their own problem-solving ability, perception of the problem's difficulty and/or the delivery system's proactive help status.

The null hypothesis was not rejected.

> Hypothesis 14: There is no significant difference in students' perceived usefulness of video guide help due to the effects of locus-of-control orientation, experience, perception of their own problem-solving ability, perception of the problem's difficulty and/or the delivery system's proactive help status.

The null hypothesis was not rejected.

Discussion

When sophisticated computer systems are used to augment human performance, users are involved with the task at hand as well as the tasks associated with the artifact in front of them, that is, the computer system itself. According to Barnard (1991), "To achieve impact, behavioral engineering research must itself directly support the design, development, and invention of artifacts" (p. 111). Norman (1991) has written that the task artifact cycle not only draws upon and contextualizes knowledge in a particular domain but also provides new knowledge to assimilate to it. Barnard (1991) suggests the use of interaction scenarios as theoretical apparatus for studying and applying cognitive theory to the design and evaluation of technology.

This study was designed to examine user characteristics which may play a role in the effectiveness of digital video-based help systems. Specifically, the user attributes related to experience and locus of control were studied. Also, the way proactive, unrequested help interacted with these user attributes was studied. Finally, user perceptions were incorporated into models designed to set the stage for future research.

The study supported the hypothesis that increasing the amount of digital video guide help that novice users receive increases the likelihood of success in the problem-solving activity. Furthermore, offering proactive (unrequested) digital video guide help increases the likelihood that users will request help on their own, and users who do request such help are more likely to solve the problem correctly.

It was hypothesized that both locus of control and experience would have a significant effect on user performance in a computerized problem space equipped with a proactive help system. Several locus-of-control studies have concluded that internally oriented individuals should perform better in problem-solving tasks than externally oriented individuals. Phares (1968, cited in Lefcourt, 1976) found that internals make better use of information than externals. Lefcourt and Wine (cited in Lefcourt, 1976) found that internals were more likely to attend to cues that resolve uncertainties. Lefcourt (1976) concluded that internals are "more inquisitive, curious, and efficient processors of information than externals" (p. 65), while Horak and Horak (1982) suggested that high internals can discriminate general principles through inductive methods when given a guided discovery scenario.

The results of this study, however, indicate that locus of control did not contribute to achievement in the problem-solving activity used in this study. The overall mean of locus-of-control measures of subjects tested was 8.5429 with a standard deviation of 4.0175, on a scale from 1 to 40. A lower index indicates a more internally oriented subject. The clearly internal position of the mean may have impacted the results. Similarly, experience had no significant direct effect on performance in this study. This lack of a significance indicates that previous computer experience does not increase the likelihood of better performance in a problem-solving activity in which the user is inexperienced. Varying the type of proactive help had no impact on the significance of either the locus-of-control or previous experience effects related to problem-solving ability. There were no significant interactions between varying help type and either locus of control or experience.

Although the results of this study indicate that locus of control and experience do not impact the likelihood of success with the problem-solving activity, locus-of-control orientation was found to be a significant predictor of whether the user will find digital video guide help useful and of whether the user will enjoy the problem-solving activity. Moreover, the more externally oriented the user, the more likely he/she will be to (a) find digital video guide help useful and (b) enjoy the activity itself. Externally oriented users also exhibited a stronger preference toward proactive help. Previous computer experience was found to have no significant effect on either perceived usefulness or enjoyment of the activity. However, the interaction between previous computer experience and locus of control had a significant effect on both perceived usefulness and enjoyment. Moreover, less experienced users rated as more external will probably find digital video guide assistance more useful and an activity incorporating such assistance more enjoyable than more experienced internally rated users.

Although the rather complex preference-based hypotheses were rejected, several significant effects were found in addition to those related to locus of control. The study's findings indicate that users who do not consider themselves good problem solvers are more likely to prefer proactive, that is, automatic, rather than manually requested digital video guide help. As the problem's perceived difficulty increases, those who perceive themselves to be good problem solvers are more likely to find digital video guide assistance helpful. Predictably, users who perceive themselves as good problem solvers are significantly more likely to enjoy the problem-solving activity, while users who perceive the problem as difficult are less likely to enjoy the activity.

Implications

The results of this study indicate that digital video guide assistance can be effective with beginners in a problem-solving activity. Since the use of agents and video guides is likely to increase, software designers should have an understanding of factors that contribute to the successful implementation of such digital characters. The variables in this study had a significant effect not only on performance but also on user attitudes. Interactions between variables, experience, and locus of control, for example, also produced significant effects. Since locus of control is a construct used in social learning theory, its application to man-machine interfaces is relatively unexplored. Whether generalizations concerning locus of control extend to the man-machine interface needs further scrutiny (M. B. Rowe, personal communication, December 22, 1993). The same can be said for other personality constructs. For example, educators and software developers could design similar studies which incorporate learning styles preference as an independent variable.

Several aspects of the man-machine dialog that merit further research were held constant in this study. For example, the digital video guide assisting every subject in this study was a white male wearing glasses and a bow tie. As another example, the proactive intervention of digital video guide assistance was given on a fixed time basis in this study. When software incorporating help features are designed and produced, an understanding of how such variables affect performance is extremely important. In fact, Shneiderman (1991) believes that the study of performance variables provides a prime opportunity for conducting fundamental research in human-computer interaction. Hopefully, future research will address such issues.

Recommendations

The following recommendations are made for future studies in the area of human-computer interaction:

1. Studies varying the sex, dress, race, speech, and gesturing of the video guide could investigate learner preference on learning.

2. Studies which attempt to find appropriate times to wait before supplying machine intervention could parallel the wait-time studies done by Rowe (1974, 1986) in classroom settings. In a sophisticated interactive environment both wait time 1 and wait time 2 could be examined. Other researchers (Teal & Rudnicky, 1992) have developed a user model composed of two events: user planning and acquisition time, and execution time. Theorists attempting an analysis of the time component of an interaction scenario will find fascinating research on the subject.

3. The effectiveness of attention-getting devices, such as gesturing cues used by a digital video guide, could be studied.

4. The effectiveness of questioning techniques could be studied in an interactive environment which monitored user action and evaluated appropriate behavior in a problem space.

5. A study could be designed to give the subjects control over certain attributes of their guide, such as age, appearance, voice, and clothing. User choices could be mapped to learning styles, personality constructs, and/or socioeconomic factors to investigate if such empowerment aids the learning process.

6. Studies could investigate the effectiveness of incorporating proactive digital video guides in alert dialogs or specific computer interactions to compare their effectiveness with text and/or other multimedia man-computer dialogs.

7. Studies which allow the user to choose proactive or manual help during a series of activities could track user preference from novice user to experienced user. Is proactive help more effective for beginners? Does proactive help enhance or interfere with the deliberations of experienced users?

8. Although often considered a gross media comparison, studies which evaluated digital video guide assistance versus text only or text and graphic assistance would be useful to software developers.

9. Due to the anthropomorphic quality of digital video guides, users may ascribe attributes to guides other than the ones intended by the guides creators (Oren, Salomon, Kreitman, & Don, 1990), that is, external traits of the digital video guide may imply internal traits related to value systems. Can a digital video guide's implied expectations affect the learner? Brenda Laurel (1990) poses the question: "How might interface agents affect the

working styles, expectations, productivity, knowledge, and personal power of those who use them" (p. 364)? Studies which examine the effect of ascribed attributes and its implications are needed.

10. Digital video guides and hand-drawn cartoon guides could be compared based on effective communication (i.e., instruction) and also on ascribed attributes.

11. Based on the number of subjects in this study who actually spoke to the digital video guide, studies evaluating digital video guides which recognize speech versus those that do not would seem worthwhile.

12. Replications of this study using subjects with a wider range of locus-of-control orientations could attend to the null hypotheses which were not rejected in this study.

Summary

The issues currently being examined in the field of human computer interaction are clearly in the domain of educational research. Previous studies investigating teacher-student interaction can be replicated using interactive computer systems and artificially intelligent software. The ability of such software to attend to the wide variety of teaching and learning styles offers fertile ground for instructional design research.

Digital video guides and agents represent a special case of the task-artifact cycle. Of special interest are the ways in which digital video guides offer unique solutions to both task-related problems and existing interface problems. For example, if there is confusion during human driven searches of a multimedia environment, there is likely to be confusion during an agent driven search. Is it possible that, due to the anthropomorphic aspects of digital video guides, user anxiety can be diminished when such confusion arises?

Since people learn and process information in different ways, providing help using audio and video tracks allows users to attend to the information using different resources. The addition of gesture, inflection, and other human characteristics to the interface provide more tools for the understanding and interpretation of the information being presented. It may be true that these human characteristics can be used effectively to offer the user redundant input channels to help clear up ambiguities. According to Laurel (1990), "The metaphor of character successfully draws our attention to just those qualities that form the essential nature of an agent: responsiveness, competence, and accessibility" (p. 359).

When help is interactive, users can request additional information and perhaps even control its mode of delivery. If artificially intelligent systems are used, the system can try to isolate the source of the problem and proactively offer a solution to the users of the system.

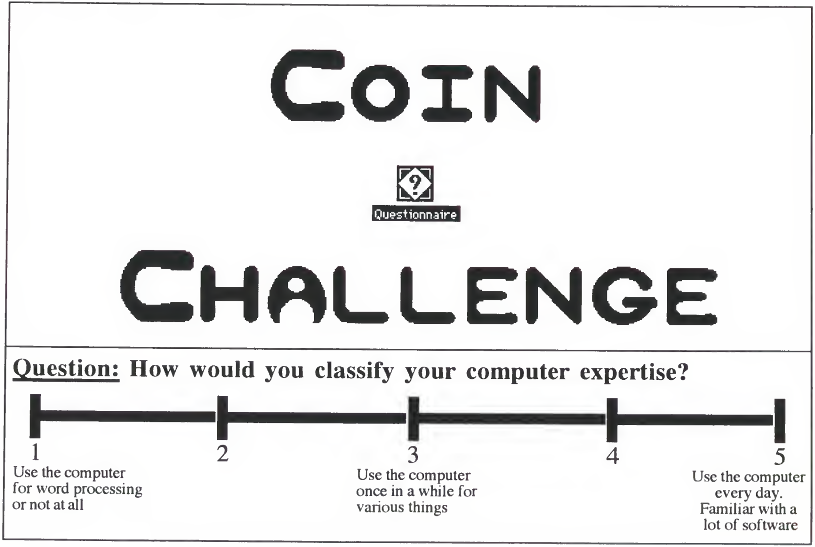
The use of a digital video guide represents a contextual forum for virtual guides that assist in the educational process, not the personification of the computer, but the virtual representation of a mediator in learning activities. To what extent a computer representation can augment the learning process remains to be seen. It does, however, seem that technology is attempting to formulate a response to the problem that Socrates pointed out to Phaedrus:

> It is the same with the written words; they seem to talk to you as if they were intelligent, but if you ask them anything about what they say, from a desire to be instructed, they go on telling you the same thing forever. (Plato, 1961, as quoted in Norman, 1993, p. 45)

This study was designed to study the impact of digital video guide help on users actively involved in a problem space. Specifically, it analyzed the effects of several variables including experience, locus of control, and proactive help status on achievement in a problem space and on user preferences. The subjects in the study were undergraduate students enrolled in an introductory instructional computing course.

The results of the study indicate that increasing the amount of digital video guide help novice users in a problem space receive increases the likelihood of success in the problem-solving activity. Providing proactive digital video guide help also increased the likelihood that users would request help more often which was shown to be related to achievement. Locus-of-control orientation was found to be a significant predictor of whether the user will find digital video guide help useful and of whether the user will enjoy the problem-solving activity.

APPENDIX A
ATTITUDE SURVEY



COIN

Questionnaire

CHALLENGE

Question: **How would you classify your computer expertise?**

1 Use the computer for word processing or not at all

2

3 Use the computer once in a while for various things

4

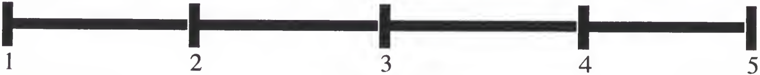
5 Use the computer every day. Familiar with a lot of software

COIN

Questionnaire

CHALLENGE

Question: **How would you rate your problem-solving ability?**



I have never been good at solving logic problems

I consider myself an average problem solver

I enjoy doing problem solving activities

COIN

Questionnaire

CHALLENGE

Question: How would you rate the game's difficulty level?

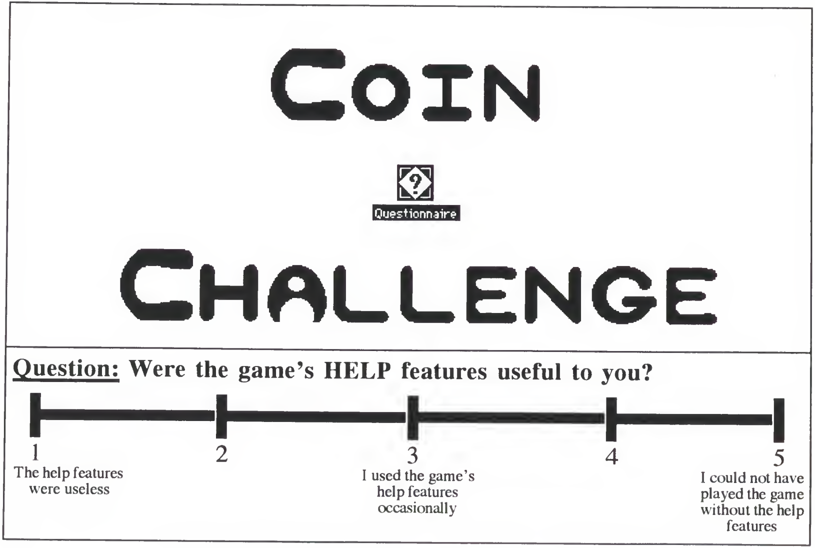
1 It was extremely easy to learn and play

2

3 It was fairly difficult to learn and play

4

5 It was very difficult to learn and play



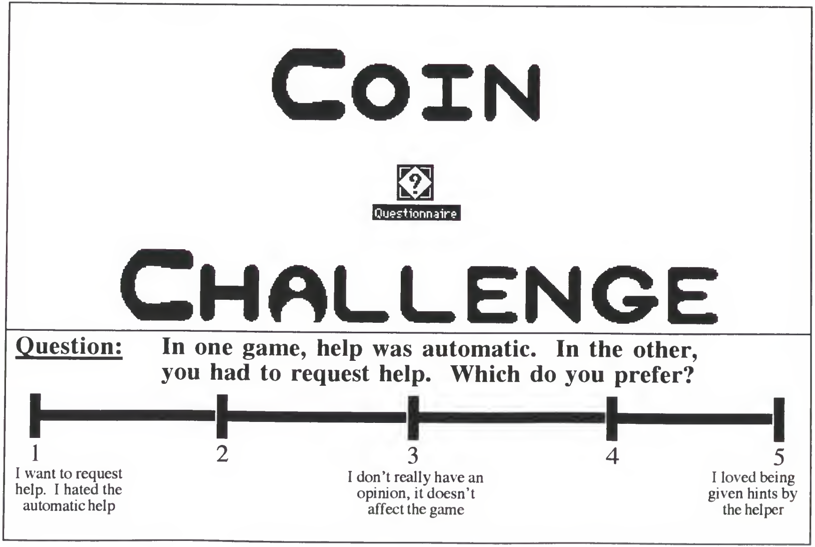
COIN

Questionnaire

CHALLENGE

Question: Were the game's HELP features useful to you?

1	2	3	4	5
The help features were useless		I used the game's help features occasionally		I could not have played the game without the help features



COIN

Questionnaire

CHALLENGE

Question: In one game, help was automatic. In the other, you had to request help. Which do you prefer?

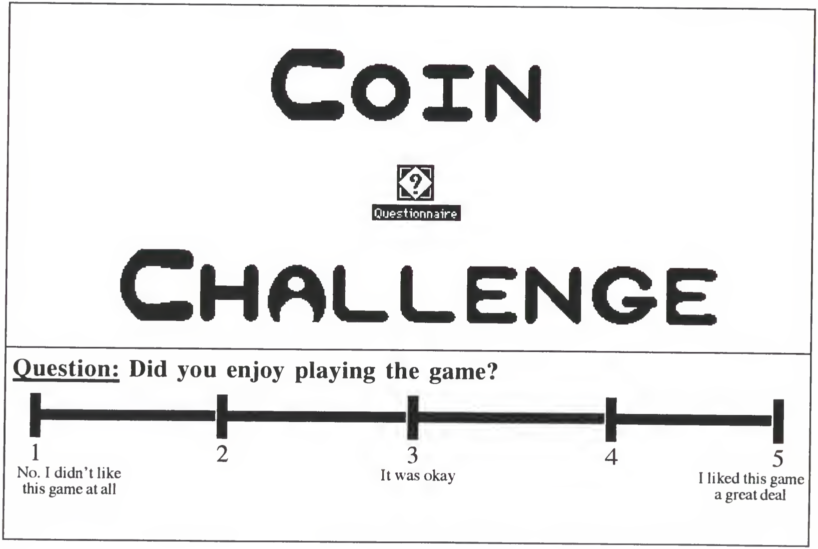
1 I want to request help. I hated the automatic help

2

3 I don't really have an opinion, it doesn't affect the game

4

5 I loved being given hints by the helper



COIN

CHALLENGE

Question: Did you enjoy playing the game?

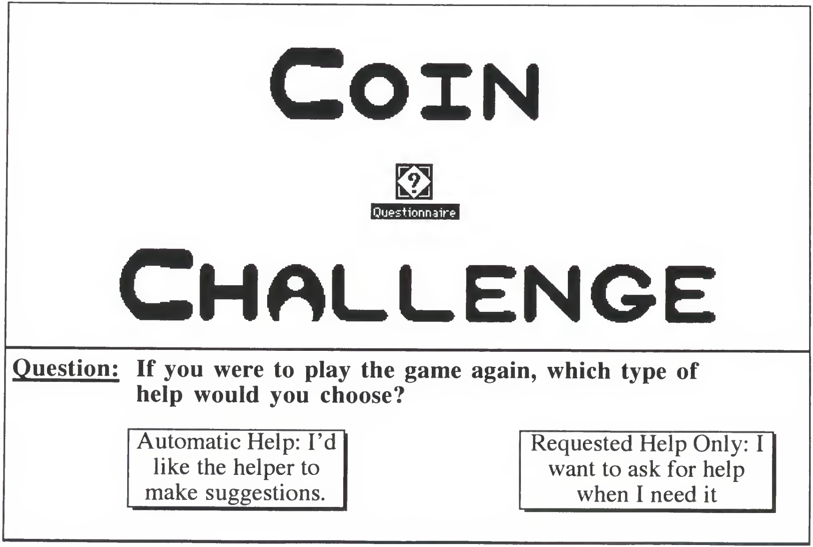
1 No. I didn't like this game at all

2

3 It was okay

4

5 I liked this game a great deal



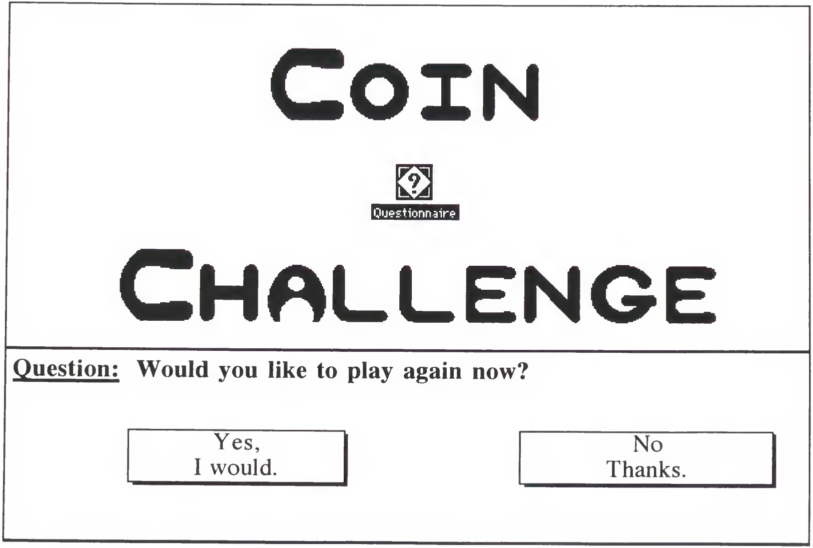
COIN

CHALLENGE

Question: **If you were to play the game again, which type of help would you choose?**

Automatic Help: I'd like the helper to make suggestions.

Requested Help Only: I want to ask for help when I need it



Question: Would you like to play again now?

APPENDIX B
COMPUTER SURVEY

Computer Survey **Identification Code: ________**

Please answer the following questions by checking the appropriate boxes.

How long have you been working with computers?

____ Less than 6 months ____ Between 6 months and 1 year

____ Between 1 and 2 years ____ More than 2 years

How would you characterize the frequency of your normal computer use?

____ I use a computer daily ____ I use a computer at least once a week
____ I use a computer a few times a semester
____ I rarely use a computer

For what activities do you normally use a computer? (Check all that apply)

____ Word Processing
____ Electronic Mail
____ Programming
____ Research
____ Drawing, Painting
____ Spreadsheets, Budgeting, Financial
____ Making Presentations
____ Work-Related Activities, On the job
____ Constructing Databases, Address Books, Appointment Calendars
____ Entertainment, Playing Games
____ Other. Please Specify ________________________________
____

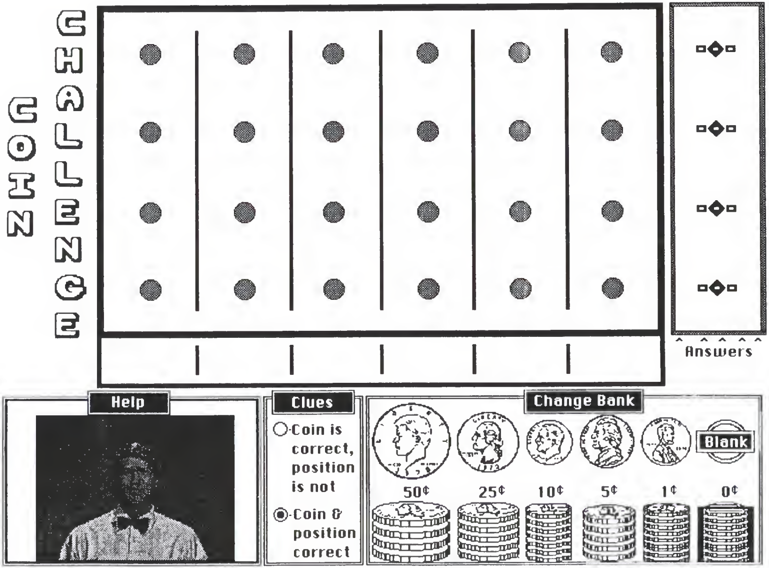
Which of these software packages have you used? (Check all that apply)

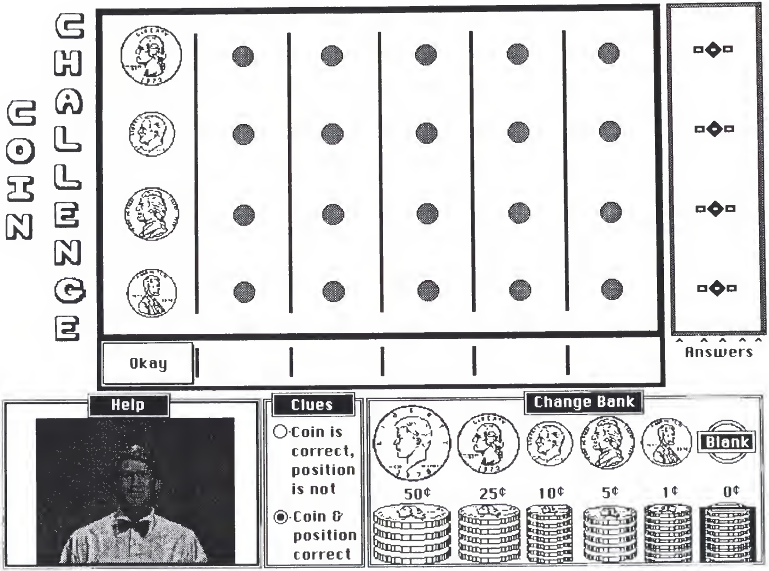
____ Microsoft Word
____ AppleWorks
____ PageMaker
____ HyperCard
____ Harvard Graphics
____ Microsoft Works
____ ClarisWorks
____ Quark
____ Toolbook
____ Lotus 1-2-3
____ Word Perfect
____ MacWrite II
____ PhotoShop
____ AutoCad
____ Microsoft Excel
____ Other. Please Specify ________________________________

Which of the following Operating Systems have you encountered?

____ DOS
____ Windows
____ Other ____________________
____ Macintosh OS
____ Unix
____ Apple DOS, ProDOS
____ Amiga DOS
____ I don't have any idea

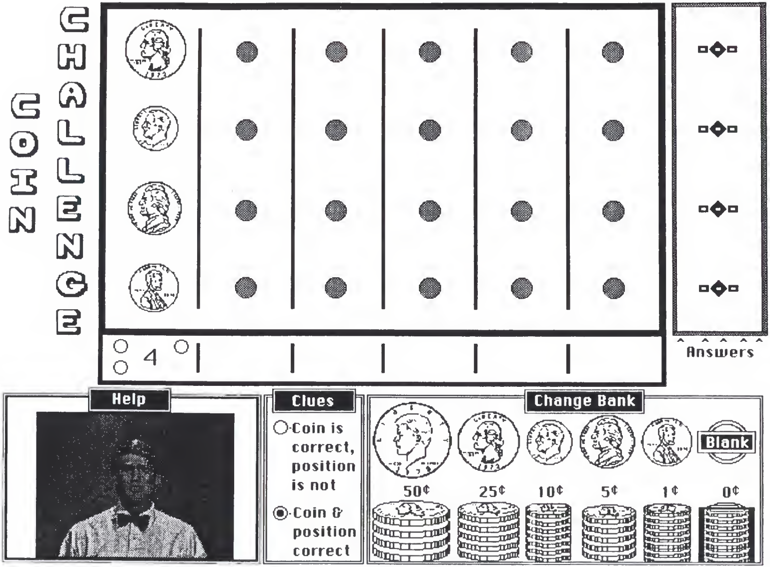
APPENDIX C
SAMPLE PROBLEM

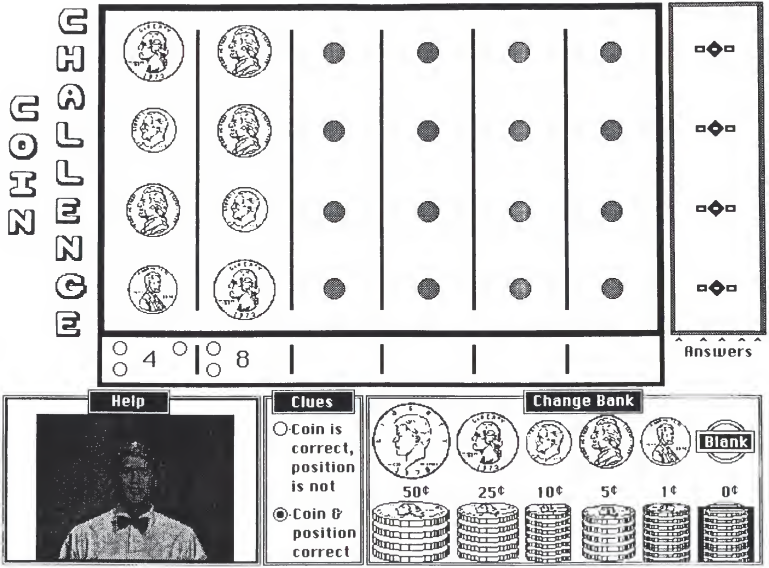

COIN
CHALLENGE
Answers
Help
Clues
○ Coin is correct, position is not
● Coin & position correct
Change Bank
Blank
50¢
25¢
10¢
5¢
1¢
0¢



○ Coin is correct, position is not

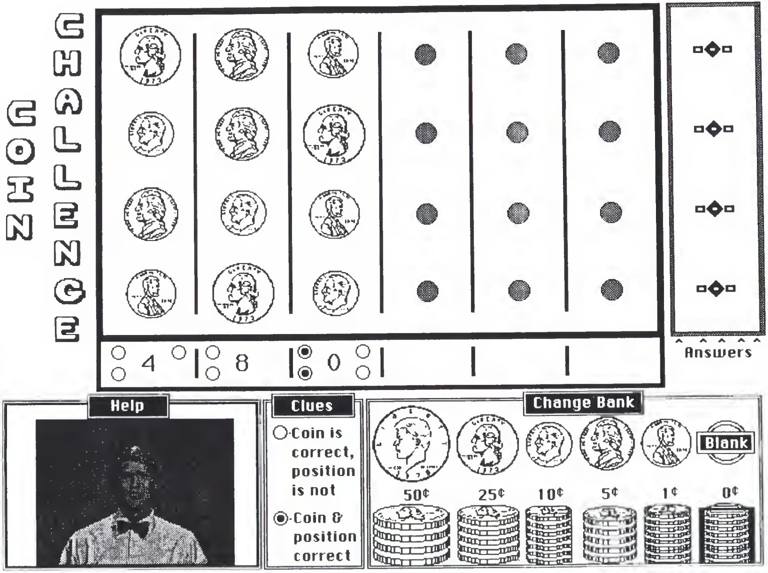
● Coin & position correct

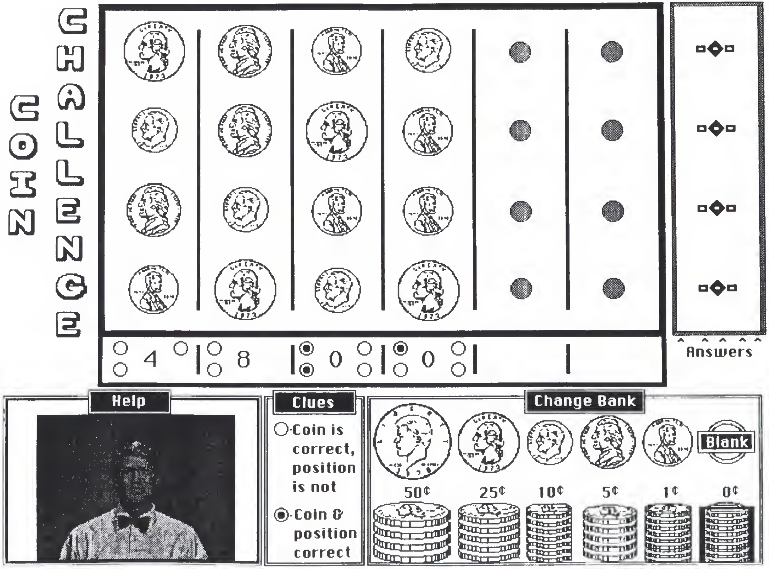

COIN
CHALLENGE
4
Answers
Help
Clues
○ Coin is correct, position is not
● Coin & position correct
Change Bank
Blank
50¢
25¢
10¢
5¢
1¢
0¢



○ Coin is correct, position is not

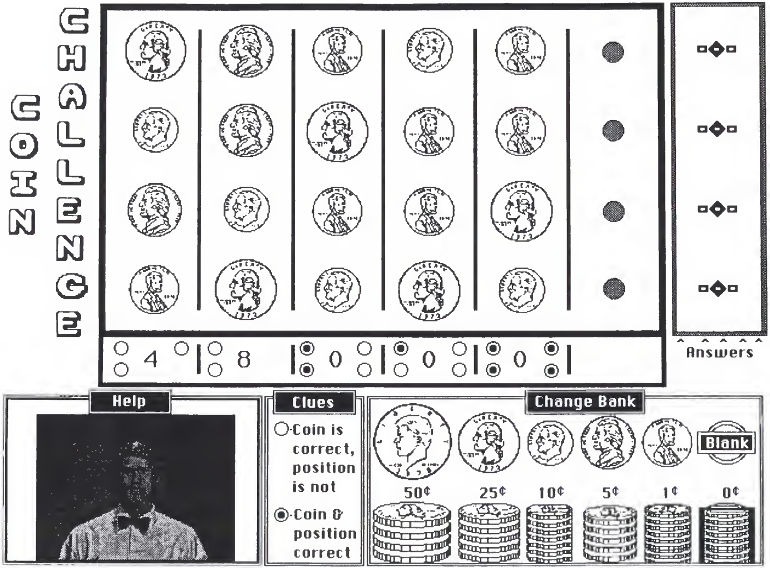
● Coin & position correct


CHALLENGE
COIN
4
8
0
Answers
Help
Clues
○ Coin is correct, position is not
● Coin & position correct
Change Bank
50¢
25¢
10¢
5¢
1¢
0¢
Blank



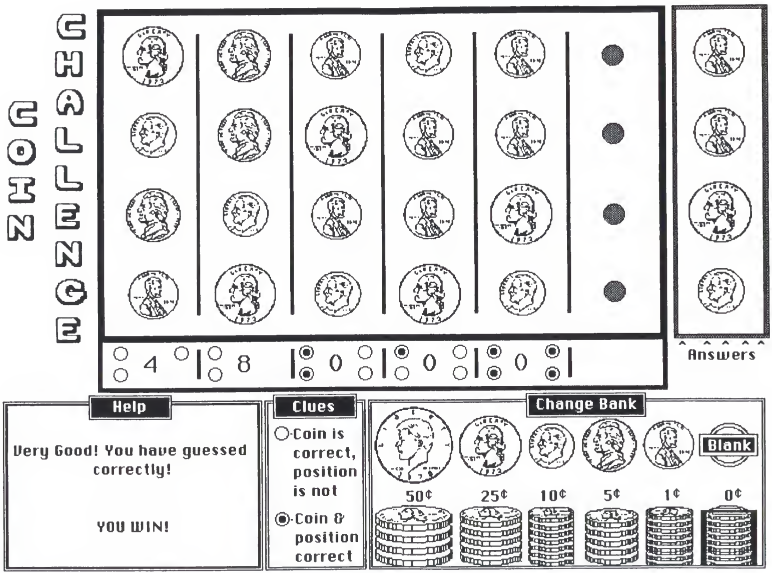
○ Coin is correct, position is not

● Coin & position correct



○ Coin is correct, position is not

● Coin & position correct



Very Good! You have guessed correctly!

YOU WIN!

REFERENCES

Agresti, A., & Finlay, B. (1986). Statistical methods for the social sciences. San Francisco: Dellen Publishing Company.

Alty, J. L., & Coombs, M.J. (1981). Communicating with university computer users: A case study. In M. J. Coombs & J. L. Alty (Eds.), Computing skills and the user interface (pp. 7-71). London: Academic Press.

Ambardar, A. K. (1984). Human computer interaction and individual differences. In G. Salvendy (Ed.), Human-computer interaction (pp. 207-211). Amsterdam, The Netherlands: Elsevier Science Publishers.

Anderson, C. L. (1988). The expert module. In M. C. Polson & J. J. Richardson (Eds.), Foundations of intelligent tutoring systems (pp. 21-53). Hillsdale, NJ: Lawrence Erlbaum Associates.

Bannon, L. J., & Bodker, S. (1991). Beyond the interface: Encountering artifacts in use. In J. M. Carrol (Ed.), Designing interaction: Psychology at the human-computer interface (pp. 227-253). Cambridge: Cambridge University Press.

Barnard, P. (1991). Bridging between basic theories and the artifacts of human-computer interaction. In J. M. Carroll (Ed.), Designing interaction: Psychology at the human-computer interface (p. 333). Cambridge: Cambridge University Press.

Bartsch, R. (1979). Semantical and pragmatical correctness as basic notions of the theory of meaning. Journal of Pragmatics, 3, 1-43.

Binsted, D. (1987). Text, talking heads, or live video. Media choice in Interactive Video. Interactive Learning International, 4(3&4), 37-41.

Bodker, S. (1989). A human activity approach to user interfaces. Human-Computer Interaction, 4(3), 171-195.

Bosser, T. (1987). Learning in man-computer interaction. Berlin: Springer-Verlag.

Branca, N. A. (1980). Problem solving as a goal, process, and basic skill. In S. Krulik & R. E. Reys (Eds.), Problem solving in school mathematics, 1980 yearbook (pp. 3-8). Reston, VA: National Council of Teachers of Mathematics.

Brown, P. J. (1983). Error messages: The neglected area of the man/machine interface? Communications of the ACM, 26(4), 246-251.

Butterfield, E. C. (1964). Locus of control, test anxiety, reactions to frustration, and achievement attitudes. Journal of Personality, 32, 355-370.

Card, S. K., Moran, T. P., & Newell, A. (1983). The psychology of human-computer interaction. Hillsdale, NJ: Lawrence Erlbaum Associates.

Carroll, J. M. (1991). Introduction: The Kittle House Manifesto. In J. M. Carrol (Ed.), Designing interaction: Psychology at the human-computer interface (pp. 1-16). Cambridge: Cambridge University Press.

Carroll, J. M., & Aaronson, A. (1989). Learning by doing with simulated intelligent help. In E. Barrett (Ed.), The society of text: Hypertext, hypermedia, and the social construction of information (pp. 423-452). Cambridge, MA: The MIT Press.

Carroll, J. M., & McKendree, J. (1987). Interface design issues for advice-giving expert systems. Communications of the ACM, 30(1), 14-31.

Cohil, A. M., & Williges, R. C. (1982). Computer-augmented retrieval of help information for novice users. Seattle, WA: The Human Factors Society.

Coombs, M. J., & Atty, J. L. (1984). Expert systems: An alternative paradigm. International Journal of Man-Machine Studies, 20(1), 21-43.

diSessa, A. A. (1986). Notes on the future of programming. In D. A. Norman & S. W. Draper (Eds.), User-centered system design: New perspectives on human-computer interaction (pp. 125-152). Hillsdale, NJ: Lawrence Erlbaum Associates.

Duffy, T. M., Mehlenbacher, B., & Palmer, J. (1989). The evaluation of online help systems: A conceptual model. In P. A. Hancock & M. H. Chignell (Eds.), Intelligent interfaces: Theory, research and design (pp. 362-387). B.V. North-Holland: Elsevier Science Publishers.

Eberts, R. E., & Eberts, C. G. (1989). Four approaches to human computer interaction. In P. A. Hancock & M. H. Chignell (Eds.), Intelligent interfaces: Theory, research, and design (pp. 69-127). B.V. North-Holland: Elsevier Science Publishers.

Engelbart, D. C. (1963). A conceptual framework for the augmentation of man's intellect. In P. W. Howerton & D. C. Weeks (Eds.), Vistas in information handling (pp. 1-29). Washington, DC: Spartan Books.

Ernst, G. W., & Newell, A. (1969). GPS: A case study in generality and problem solving . New York: Academic Press.

Feuerstein, R. (1990). The theory of structural cognitive modifiability. In R. McClure (Ed.), Learning and thinking styles: Classroom interaction (pp. 68-134). Washington, DC: National Education Association and Research for Better Schools.

Fischer, G., Lemke, A., & Schwab, T. (1985). Knowledge-based help systems. San Francisco: ACM.

Gallimore, R., & Tharp, R. (1990). Teaching mind in society: Teaching, schooling, and literate discourse. In L. C. Moll (Ed.), Vygotsky and education: Instructional implications and applications of socio-historical psychology (pp. 175-205). Cambridge: Cambridge University Press.

Gay, L. R. (1992). Educational research: Competencies for analysis and application (4th ed.). New York: Merrill, an imprint of Macmillan Publishing Company.

Genesereth, M. R. (1983). An overview of meta-level architecture. Washington, DC: Morgan Kaufman Publishers Inc.

Gombrich, E. H. (1974). The visual image. In D. R. Olson (Ed.), Media and symbols: The forms of expression, communication, and education. (pp. 241-270). Chicago, IL: University of Chicago Press.

Goodman, S. H., & Waters, L. K. (1987). Convergent validity of five locus of control scales. Educational and Psychological Measurement, 47(3), 743-747.

Hammond, N., & Barnard, P. (1984). Dialogue design: Characteristics of user knowledge. In A. Monk (Ed.), Fundamentals of human-computer interaction (pp. 127-164). Orlando, FL: Academic Press, Inc.

Horak, V. M., & Horak, W. J. (1982). The influence of student locus of control and teaching method on mathematics achievement. Journal of Experimental Education, 51(11), 18-21.

Hosmer, D. W., & Lemeshow, S. (1989). Applied logistic regression. New York: John Wiley and Sons.

Jackson, P., & Lefrere, P. (1984). On the application of rule-based techniques to the design of advice giving systems. International Journal of Man-Machine Studies, 20, 63-86.

Johnson, B. L., & Kilmann, P. B. (1975). Locus of control and perceived confidence in problem-solving abilities. Journal of Clinical Psychology, 31(1), 54-55.

Jones, M., & Wipond, K. (1990). Curriculum and knowledge-based system for curriculum development. Educational Technology, 30(3), 7-14.

Joyce, B. (1980). Learning how to learn. Theory Into Practice, 19(1)(Winter, 1980), 15-27.

Kahneman, D. (1973). Attention and effort. Englewood Cliffs, NJ: Prentice Hall.

Kantowski, M. G. (1977). Processes involved in mathematical problem solving. Journal for Research in Mathematics Education, 8(May 1977), 163-180.

Kantowski, M. G. (1980). Some thoughts on teaching for problem solving. In S. Krulik & R. E. Reys (Eds.), Problem solving in school mathematics: 1980 NCTM yearbook (pp. 195-203). Reston, VA: The National Council of Teachers of Mathematics.

Kasher, A. (1977). What is a theory of use? Journal of Pragmatics, 1, 105-120.

Kay, A. (1984, September). Computer software. Scientific American, pp. 52-59.

Kieras, D., & Polson, P. G. (1985). An approach to the formal analysis of user complexity. International Journal of Man-Machine Studies, 20, 201-213.

Knox, S. T., Bailey, W.A, & Lynch, E. F. (1989). Human factors in computing systems: CHI '89. Austin, TX: Addison-Wesley.

Laurel, B. (1990). Interface agents. In B. Laurel (Ed.), The art of human-computer interface design (pp. 355-365). Reading, MA: Addison-Wesley.

Laurel, B. (1991). Computers as theatre. Reading, MA: Addison-Wesley.

Lefcourt, H. M. (1976). Locus of control: Current trends in theory and research. Hillsdale, NJ: Lawrence Erlbaum Associates.

Leith, G. O. M. (1973). The effects of extraversion and methods of programmed instruction on achievement. Educational Researcher, 15, 150-153.

Louie, S., Luick, A., & Louie, J. (1986). Locus of control among computer-using school children: A report of a pilot study. Educational Technology Systems, 14(2), 101-118.

Martin, C. (1988). User-centered analysis. Englewood Cliffs, NJ: Prentice Hall.

McLeod, P. (1977). A dual task response modality effect: Support for mulitprocessor models of attention. Quarterly Journal of Experimental Psychology, 67, 651-667.

Merrill, M. D. (1987). The new component theory: Instructional design for courseware authoring. Instructional Science, 16(1), 19-34.

Miyata, Y., & Norman, D. A. (1986). Psychological issues in support of multiple activities. In D. A. Norman & S. W. Draper (Eds.), User-centered system design: New perspectives on human-computer interaction (pp. 265-284). Hillsdale, NJ: Lawrence Erlbaum Associates.

Moran, T. P. (1981). The command language grammar: A representation for the user interface computer system. International Journal of Man-Machine Studies, 15, 3-50.

Mountford, S. J., & Gaver, W. W. (1990). Talking and listening to computers. In B. Laurel (Ed.), The art of human-computer interface design (pp. 319-334). Reading, MA: Addison-Wesley.

Navon, D., & Gopher, D. (1979). On the economy of the human processing system. Psychological Review, 86, 214-253.

Newell, A., Simon, H. A., & Shaw, K. (1958). Elements of the theory of human problem solving. Psychological Review, 65(3), 151-166.

Newell, A., & Simon, H. S. (1972). Human problem solving. Englewood Cliffs, NJ: Prentice Hall.

Norman, D. A. (1983). Some observations on mental models. In D. Gentner & A. L. Stevens (Ed.), Mental models (pp. 7-14). Hillsdale, NJ: Lawrence Erlbaum Associates.

Norman, D. A. (1984). Cognitive engineering principles in the design of human-computer interfaces. Honolulu, HI: Elsevier Science Publications.

Norman, D. A. (1988). The psychology of everyday things. New York: Basic Books.

Norman, D. A. (1991). Cognitive artifacts. In J. M. Carroll (Ed.), Designing Interaction: Psychology at the human-computer interface (pp. 17-38). Cambridge: Cambridge University Press.

Norman, D. A. (1993). Things that make us smart: Defending human attributes in the age of the machine. Reading, MA: Addison-Wesley Publishing Company.

Norman, D. A., & Draper, S. W. (1986). User-centered system design. Hillsdale, NJ: Lawrence Erlbaum Associates.

Nowicki, S., & Duke, M. (1974). A locus of control scale for non-college as well as college adults. Journal of Personality Assessment, 38(2), 136-137.

Ohlsson, S. (1987). Some principles of intelligent tutoring. In R. W. Lawler & M. Yazdani (Eds.), Artificial intelligence and education, volume one (pp. 203-237). Norwood, NJ: Ablex Publishing Corporation.

Oren, T., Salomon, G., Kreitman, K., & Don, A. (1990). Guides: Characterizing the interface. In B. Laurel (Ed.), The art of human computer interface design (pp. 367-382). Reading, MA: Addison-Wesley.

Osgood, C. E., Soci, G. J., & Tannenbaum, P. H. (1957). The measurement of meaning. Urbana, IL: University of Illinois Press.

Papert, S. (1980). Mindstorms: Children, computers, and powerful ideas. New York: Basic Books.

Pea, R. D. (1988). Putting knowledge to work. In R. S. Nickerson & P. P. Zodhiates (Eds.), Technology in education: Looking toward 2020 (pp. 330). Hillsdale, NJ: Erlbaum Associates.

Pirolli, P., & Russell, D. M. (1990). The instructional design environment: Technology to support design problem solving. Instructional Science, 19, 121-144.

Polson, P. G. (1987). A quantitative theory of human-computer interaction. In J. M. Carroll (Ed.), Interfacing thought (pp. 184-235). Cambridge, MA: MIT Press.

Polya, G. (1962). Mathematical discovery. New York: John Wiley & Sons.

Prawat, R. S., Grissom, S., & Parish, T. (1979). Affective development in children, grades 3 through 12. Journal of Genetic Psychology, 135(1), 37-50.

Ramey, J. (1989). Escher effects in online text. In E. Barrett (Ed.), The society of text: Hypertext, hypermedia, and the social construction of information (pp. 388-402). Cambridge, MA: The MIT Press.

Robinson, C. P., Base, S. J., & Eberts, R.E. (1985). Eyes/ears; Spacial/verbal: How should a cockpit talk to a pilot. In R. E. Eberts & C. G. Eberts (Eds.), Trends in human factors/ergonomics (pp. 51-58). Amsterdam: Elsevier.

Robinson, F. G., Tickle, J., & Brison, D. W. (1972). Inquiry training: Fusing theory and practice. Toronto: Ontario Institute for Studies in Education.

Rotter, J. B. (1966). Generalized expectancies for internal versus external control of reinforcement. Psychological Monographs: General and Applied, 80, 1-28.

Rowe, M. B. (1974). Relation of wait-time and rewards to the development of language, logic, and fate control: Part one--Wait time. Journal of Research in Science Teaching, 11(3), 81-94.

Rowe, M. B. (1986). Wait time: Slowing down may be a way of speeding up! Journal of Teacher Education, (January-February), 43-50.

Sall, J., Ng K., & Hecht, M. (1991). JMP: Statistical visualization for the Macintosh™. Cary, NC: SAS Institute Inc.

Salomon. (1988). AI in reverse: Computer tools that become cognitive. New Orleans, LA.: EDRS.

Salomon, G., Perkins, D., & Globerson, T. (1991). Partners in cognition: Extending human intelligence with intelligent technologies. Educational Researcher, (April, 1991), 2-9.

SAS Institute. (1989). JMP© user's guide. Cary, NC: The SAS Institute Inc.

Schoen, D. (1982). The reflective practitioner: How professionals think in action. New York: Basic Books.

Schoenfeld, A. H. (1980). Heuristics in the classroom. In S. Krulik & R. E. Reys (Eds.), Problem solving in school mathematics, 1980 yearbook (pp. 9-22). Reston, VA: National Council of Teachers of Mathematics.

Shadbolt, D. (1978). Interactive relationships between measured personality and teaching strategy variables. British Journal of Educational Psychology, 48(June 1978), 227-231.

Shneiderman, B. (1982). System message design: Guidelines and experimental results. In A. Badre & B. Shneiderman (Eds.), Directions in human/Computer interactions (pp. 55-78). Norwood, NJ: Ablex.

Shneiderman, B. (1987). Designing the user interface: Strategies for effective human-computer interaction. Reading, MA: Addison Wesley.

Shneiderman, B. (1991). Human values and the future of technology: A declaration of responsibility. ACM SIGCHI Bulletin, 23(1), 6-10.

Simon, H. A., & Kotovsky, K. (1963). Human acquisition of concepts for sequential patterns. Psychological Review, 70, 534-546.

Slayton, W. M. (1984). Locus of control orientation of preschool children of low income families of various ethnic groups. Ann Arbor, MI: University Microfilms International.

Teal, S. L., & Rudnicky, A. I. (1992). A performance model of system delay and user strategy selection. Monterey, CA: The Association for Computing Machinery, Inc.

Thimbleby, H. (1984). User interface design: Generative user engineering principles. In A. Monk (Ed.), Fundamentals of human-computer interaction (pp. 165-180). Orlando, FL: Academic Press, Inc.

Turkle, S. (1984). The second self: Computers and the human spirit. New York: Simon & Schuster, Inc.

VanLehn, K. (1990). Mindbugs: The origins of procedural misconception. Cambridge, MA; London, England: MIT Press.

Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes. Cambridge, MA: Harvard University Press.

Waterworth, J. (1984). Speech communication: How to use it. In A. Monk (Ed.), Fundamentals of human-computer interaction (pp. 221-236). Orlando, FL: Academic Press, Inc.

Whiteside, J., & Wilson, D. (1987). Improving human-computer interaction: A quest for cognitive science. In J. Carrol (Ed.), Interfacing thought (pp. 353-365). Cambridge, MA: MIT Press.

Wickens, C. D. (1980). The structure of attentional resources. In R. Nickerson (Ed.), Attention and performance (pp. 239-257). Hillsdale, NJ: Lawrence Erlbaum Associates.

Wickens, C. D., Sandry, D., & Vidulich, M. (1983). Compatibility and resource competition between modalities of input, central processing, and output: Testing a model of complex task performance. Human Factors, 25, 227-248.

Wildstein, A. B. (1982). Locus of control, expectational set, on two aptitude measures. Paper presented at the 90th Annual Meeting of the American Psychological Association, Washington, DC.

Winograd, T., & Flores, F. (1986). Understanding computers and cognition: A new foundation for design. Norwood, NJ: Ablex.

Woolf, B. (1988). Intelligent tutoring systems: A survey. In H. E. Shrobe & American Association for Artificial Intelligence (Eds.), Exploring artificial intelligence (pp. 1-44). San Mateo, CA: Morgan Kaufmann Publishers, Inc.

Wright, P. (1989). Varieties of strategic reading: Some interface requirements. Machine-Mediated Learning: An International Journal, 3(3), 279-288.

BIOGRAPHICAL SKETCH

Sebastian Foti was born in Jamestown, New York, on June 17, 1949. He received his Bachelor of Arts degree in mathematics and his Master of Science degree in general science education from the State University College at Buffalo, New York, in 1971 and 1973, respectively. He received his Second Dan Black Belt in Tae Kwon Do from the World Tae Kwon Do Federation in 1989.

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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